ASSOCIAÇÃO DE POLITÉCNICOS DO NORTE **(APNOR)**

INSTITUTO POLITÉCNICO DE BRAGANÇA

The impact of the digital leadership ecosystem on changing management profiles

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Bragança, May 2024.

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Abstract

This research aimed to determine the impact of the digital leadership ecosystem on the change of management profiles in companies located and operating in the Volyn region of Ukraine. According to the results of digital transformation in the regions of Ukraine, Volyn region entered the TOP-5 and took the 4th place with an index of 0.831, maximum – 1 (Ministry of Digital Transformation of Ukraine, 2024).

This research was based on a survey of company executives in Volyn Oblast. The survey consisted of two parts. The first part was a survey in Google form, where respondents had to rate on a 5-point scale the level of digitalization of their own company, the level of their digital skills and competencies, and the level of transition from a traditional leadership model to a digital one. The second part of the survey was based on online interviews in the form of open-ended questions.

20 executives from Volyn companies from various industries, who held various leadership positions in small, medium, or large companies, were interviewed. The results were visually presented and systematized using tables, graphs, and diagrams.

Respondents interpreted the nature of the digital leadership ecosystem in different ways, which points to a gap in the scientific sector, as there is currently no unified scientific approach to understanding the digital leadership ecosystem and its components. This creates difficulties for its application in practice, for example, half of the surveyed respondents indicated that their companies do not have a digital strategy. It was found that corporate culture can drive or hinder the implementation of digital initiatives. External crises, such as COVID-19 and the full-scale russian invasion of Ukraine, have spurred the development of digitalization in companies, but they have come at a high cost to all of us.

Keywords: digital, leadership, ecosystem, impact, manager.

Resumo

Esta investigação teve como objetivo determinar o impacto do ecossistema de liderança digital na mudança de perfis de gestão em empresas localizadas e a operar na região de Volyn, na Ucrânia. O De acordo com os resultados da transformação digital nas regiões da Ucrânia, a região de Volyn entrou no TOP-5 e ocupou o 4.º lugar com um índice de 0,831, máximo – 1 (Ministério da Transformação Digital da Ucrânia, 2024).

Esta pesquisa foi baseada em uma pesquisa com executivos de empresas no Oblast de Volyn. A pesquisa consistiu em duas partes. A primeira parte foi um inquérito no formulário Google, onde os inquiridos tiveram que avaliar numa escala de 5 pontos o nível de digitalização da sua própria empresa, o nível das suas aptidões e competências digitais e o nível de transição de um modelo de liderança tradicional para um digital. A segunda parte da pesquisa baseou-se em entrevistas online na forma de perguntas abertas.

Foram entrevistados 20 executivos de empresas de Volyn de vários sectores, que ocupavam vários cargos de liderança em pequenas, médias ou grandes empresas. Os resultados foram apresentados visualmente e sistematizados através de tabelas, gráficos e diagramas.

Os inquiridos interpretaram a natureza do ecossistema de liderança digital de diferentes formas, o que aponta para uma lacuna no sector científico, uma vez que não existe atualmente uma abordagem científica unificada para compreender o ecossistema de liderança digital e os seus componentes. Isto cria dificuldades para a sua aplicação na prática, por exemplo, metade dos inquiridos indicou que as suas empresas não têm uma estratégia digital. Verificou-se que a cultura empresarial pode impulsionar ou dificultar a implementação de iniciativas digitais. As crises externas, como a COVID-19 e a invasão russa em grande escala da Ucrânia, estimularam o desenvolvimento da digitalização nas empresas, mas tiveram um custo elevado para todos nós.

Palavras-chave: digital, liderança, ecossistema, impacto, gestor.

Анотація

Дане дослідження мало на меті визначити вплив екосистеми цифрового лідерства на зміну управлінських профілів в компаніях, які розташовані та працюють у Волинській області України. За результатами цифрової трансформації в регіонах України Волинська область увійшла в ТОП-5 та зайняла 4 місце із індексом 0,831, максимум – 1 (Міністерство цифрової трансформації України, 2024).

Дане дослідження базувалось на проведенні опитування керівників компаній Волинської області. Опитування складалось з двох частин. Перша частина – опитування у Google формі, де респондентам потрібно було оцінити за 5-ти бальної шкалою рівень цифровізації власної компанії, рівень власних цифрових навичок та компетенцій, рівень переходу від традиційної моделі лідерства до цифрової. Друга частина опитування базувалась на проведенні онлайн-інтерв'ю у форматі відкритих запитань.

Було опитано 20 керівників Волинських компаній із різних галузей, які займали різні керівні посади в малих, середніх або великих компаніях. Отримані результати були візуально представлені та систематизовані за допомогою таблиць, графіків та діаграм.

Респонденти по різному інтерпретували сутність екосистеми цифрового лідерства, що вказує на прогалину в науковому секторі, адже на даний час не існує єдиного наукового підходу до розуміння екосистеми цифрового лідерства та її складових. Це створює труднощі до її застосування на практиці, наприклад, половина із опитаних респондентів вказали на те, що у їхніх компанії немає цифрової стратегії. Було встановлено, що корпоративна культура може стимулювати або гальмувати впровадження цифрових ініціатив. Зовнішні кризи, такі як COVID-19 та повномасштабне вторгнення росіян в Україну стали поштовхом для розвитку цифровізації у компаніях, проте дались вони занадто великою ціною для усіх нас.

Ключові слова: цифровий, лідерство, екосистема, вплив, керівник.

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Introduction

The aim of the work was the impact of the digital leadership ecosystem on the change in managerial profiles. The objectives were to determine the consequences of this impact on the personal qualities and skills of the manager, his or her management practices, and interaction with subordinates.

This work was based on surveying the heads of companies working in the Volyn region of Ukraine. Since the research was more focused on collecting, analyzing, and interpreting non-numerical data to gain a deeper understanding of the impact of the digital leadership ecosystem on changing management profiles, 20 managers were interviewed. This group included managers from various industries who held various management positions in small, medium, or large companies. Respondents had different levels of competence and experience in the field of digital management.

The survey was conducted in two stages. The first stage was a survey in a Google form, which consisted of two sections. In the first section, managers had to fill in personal data – name, position, age, economic sector of their company, and number of employees in the company at the current moment. The second part of the survey in the Google form was based on managers' assessment on a 5-point scale (1 – very low level, 5 – very high level) of the level of digitalization in their company, the level of their digital skills and competencies, the level of transition from the traditional leadership model to digital or innovative. Also, in this part, the respondents had to choose the type of digital leadership ecosystem that operates in their organisation, personal qualities, and skills that are needed to build and/or improve the digital leadership ecosystem. In the second stage of the survey, an online interview was conducted in the format of open questions, which allowed managers to freely express their own thoughts and views. This section provided an opportunity to deeply analyse the essence of the ecosystem of digital leadership in each company of the respondents and to make an in-depth analysis of the consequences of its influence.

The first section, which presented the results of this research, was the Profile of respondents. In this section, the personal data of managers was systematized. The second section of this work contained an analysis of the level of digital literacy of the interviewed managers and the level of digital transformation in the organisation. The third section was devoted to the influence of the ecosystem of digital leadership and consisted of 4 subsections:

1). Respondents' understanding of the nature of the digital leadership ecosystem, and examples of challenges and benefits they faced when adapting to the digital leadership ecosystem.

2) The influence of the digital leadership ecosystem on the change of personal qualities and skills of interviewed managers, their management practices, and interaction with employees.

3) The impact of corporate culture on the implementation of digital initiatives.

4) Digital strategy – its presence or absence in respondent companies. If a digital strategy was present, its type, focus, and substance.

The third and final section, which presented the results of this research, was the impact of the COVID-19 pandemic and the full-scale russian invasion of Ukraine on the formation and/or improvement of the digital leadership ecosystem and the work of companies in general.

Thus, each section of this work complemented the content of the previous one and allowed a deeper understanding of the influence of the digital leadership ecosystem, the consequences of this influence, and the factors that influence the formation and/or improvement of the digital leadership ecosystem.

1. Literature Review

1.1. Digital Leadership Ecosystem

1.1.1. Scientists' views on understanding digital leadership

The continuous development of digital technologies generates an inevitable digital transformation of jobs, business processes, business models, and business behaviour, which at the same time leads to their transformation. This requires not only new skills, abilities, and knowledge from managers to ensure the efficiency of the company and the team, but also from employees, and team members. To encourage people to achieve the desired results, a company needs a digital leader who can make the right decisions and will be a motivator and catalyst for digital change in the organisation (Westerman, Bonnet & McAfee, 2014).

Voitko and Melnichenko (2021) define leadership as the successful use of the influence of a management entity (manager) to motivate employees to achieve goals, implement a strategy, and carry out an organisation's mission; and the concept of 'leader' in the entrepreneurial environment is identified with the concept of 'leader' and indicates that it primarily concerns the sphere of management.

Some other scientists, including Bennis (1985), support the idea that leadership is not only about management, but also about influence, inspiration, and motivation. He believes that leadership can be entrusted to anyone who has official power, but leadership is something more, it's about the ability to influence others, motivate them to achieve common goals, and lead them to success, despite the absence or presence of official power in this person. He points out the difference between leadership, as a formal concept, and leadership as an inner quality of the individual. Yukl (2012) draws attention to the leadership paradigm and points out that it is not limited to 'heroic leaders' but focuses on the interaction of the leader and followers, as well as his influence on the environment. Here are two statements that confirm this: 'Contemporary research on leadership focuses more on the influence process between leaders and followers, and it often emphasizes leadership behaviors rather than the traits or characteristics of individual leaders' (Yuki, 2012, p 13); 'Rather than focusing on the personality and characteristics of leaders, modern research examines how leadership emerges from the interactions between leaders and followers and the situation in which they operate' (Yuki, 2012, p 16).

Thus, we can conclude that a leader is a person who has certain personal qualities, skills, abilities, and knowledge, but it cannot be said that you are either 'doomed to leadership' or 'completely incapable of being a leader.' Habits can be acquired, and skills can be developed. People can make changes in their personal qualities through conscious work on themselves, developing skills, increasing their level of education, and changing behavior. So, anyone can become a leader – improving and developing. And

this is not a ‘natural gift or a ‘feature from birth.’ However, this requires space and the ability to ‘express themselves’ in the company, as well as a team of like-minded people who will inspire and support.

Bennis (1985) made two statements: managers do the right thing, and leaders do the right thing; the activities and behaviors of a manager focus on controlling, organizing, planning, and coordinating, while the behaviors and tasks of a leader focus on vision, innovation, motivation, change, and trust. Already at that time, these quotes traced two key ideas about what distinguishes an ordinary manager from a manager who is also a leader for his subordinates – the ability to ‘look beyond’, to go beyond (take risks), and openness to new things, search for innovation, and continuous improvement (to be a change agent). Today, these traits are among the key characteristics of a digital leader.

The development of digital transformation has caused a change in approaches to leadership, opening up a new model known as digital leadership. First of all, it is worth noting the difference between digital leadership and electronic, which can be mistakenly identified. Both models of leadership are related to the use of technology, but they focus on a completely different one. Electronic leadership focuses on the use of electronic means of communication and information for leadership (use of e-mail, online conferences, Internet platforms, etc.), digital leadership is a broader concept that covers not only the use of electronic means of communication but also the use of technology in business management in general (data analytics, artificial intelligence, etc.), to achieve the strategic goals of the company. For example, digital transformation of the whole company or individual units can be carried out, and short-term and long-term digital strategies, innovative products, or services can be developed. Avolio and Kahai (2003) considered electronic leadership as a dynamic, reliable system built into a larger organisational system.

So, digital leadership is a large concept, one of the elements of which can be electronic leadership. The main difference between these concepts is that electronic leadership is concentrated on the use of electronic tools of communication, and digital covers a wider range of use of technology to achieve strategic goals.

Scientists interpret the concept of ‘digital leadership’ differently, based on digitalization, digital technologies, the company, and the environment in which it will be applied, based on existing theories and leadership styles. The views of some scientists are given in Table 1.

Table 1. Definition of digital leadership

Author and year of publication	Definition
De Waal, Van Outvorst and Ravesteyn (2016)	Digital leadership is a combination of a transformation leadership style and the use of digital technology
El Sawy, Amsinck, Kræmmergaard and Vinther (2016, p 142)	'Doing the right things for the strategic success of digitalization for the enterprise and its business ecosystem'
Larjovuori, Bordi, Mäkiniemi and Heikkilä-Tammi (2016, p 1144)	'Digital leadership implies the ability to involve all members of the organisation in the digitalization process, and to recognize and develop the skills and abilities needed to carry it out'
Oberer and Erkollar (2018, p 409)	'Digital leadership (leadership 4.0) is a fast, cross-hierarchical, team-oriented, and cooperative approach, with a strong focus on innovation. The personal competence of the leader, their mindset as well as their ability to apply new methods and instruments such as design thinking, are critical dimensions for 4.0 leaders'
Wasono and Furinto (2018, p 126)	'In terms of the digital leadership, the concept is created by combining the leadership skill and the digital capability to optimize the benefit of digital technology in order to increase the business performance'
Klein (2020, p 886)	'Digital leadership means leading the digital transformation process but also leading an organisation in a digital environment depending on which digital maturity level the organisation has.'
Sagbas and Erdogan (2022, p 25)	'Digital leadership is a leadership style exemplified by individuals who have innovative ideas in the digital environment, motivate their employees in the digital environment, communicate with their employees in a sustainable manner even in the digital environment, and are capable of developing digital strategies.'
Morgan and Papadonikolaki (2022)	Digital leadership is about steering organisations to take the advantages presented by digital innovations
Gledson, Zulu, Saad and Ponton (2024, p 358-359)	'Digital leadership is the action of leading a group of people or an organisation involving the use of computer technology'

Source: Author's own elaboration.

De Waal, Van Outvorst and Ravesteyn (2016) define digital leadership as a combination of a transformational leadership style using digital technologies. Korejan and Shahbazi (2016, p 453) defined transformational leadership as follows: 'Transformational leadership is a complex and dynamic process in which leaders influence their followers' values, beliefs and goals'. Transformational leadership is not only about the influence of the leader on the values, beliefs, and goals of his followers, in particular only because, to influence someone correctly, the leader should first change himself per the desired goal. After all, the impact can be both negative and positive. That is why transformational leadership is a style of leadership that aims to stimulate change in the manager/leader as a person and at the same time in subordinates to achieve a common goal through innovation, shared responsibility, and cooperation. Quite often in this approach, transformational leaders are inspirations for their subordinates, who help them develop their own potential, and contribute to personal changes and changes throughout the

organisation. De Waal, Van Outvorst and Ravesteyn (2016) in their definition, literally equates the concepts of digital and transformational leadership, indicating only the difference in the use of digital technologies. It is rather difficult to clearly define the boundaries between digital and transformational leadership because there is no single concept for their interpretation. However, in my opinion, the use of digital technologies is only one of the characteristics of digital leadership, but not the main difference from transformational leadership. To my mind, there are several key differences between these concepts: 1) digital leadership can focus mainly on digital innovation, while transformational leadership promotes innovation in all aspects of the organisation, not only in the field of technology; 2) digital leadership can induce organisational and cultural changes because any changes in the organisation are interdependent, but it does not set itself such tasks, while transformational involves changing the culture, strategies, approaches and methods of work with the possibility of using digital technologies, but not limited to them. 3) based on the previous statement, transformational changes may require more time, effort to implement, and participation of the entire organisation and are difficult to measure, while digital initiatives may be more specific, faster, and easier to implement, for example, the implementation of a short-term digital strategy that involves the introduction of certain technological approaches and the implementation of specific digital solutions.

Thus, digital leadership can include elements of transformational leadership, but it does not necessarily cover all its aspects, while transformational leadership may include the use of digital technologies, but it is not limited to them, because the focus is on deeper and broader changes in the organisation.

Oberer and Erkollar (2018) in defining digital leadership focus on innovation and leadership competence, while Larjovuori, Bordi, Mäkiniemi and Heikkilä-Tammi (2016) on the ability to attract employees, recognize and develop their skills, and abilities.

One of the key aspects is management (Klein, 2020; Gledson, Zulu, Saad & Ponton, 2024), the ability to guide the organisation to take advantage of digital innovation (Morgan & Papadonikolaki, 2022), a combination of leadership skills and digital capabilities (Wasono & Furinto, 2018), the strategic success of digitalization for the enterprise and its business ecosystem (El Sawy, Amsinck, Kræmmergaard & Vinther, 2016). Brunner, Tobias and Lehmann (2023) in their work, they systematized the definition of the concept of digital leadership from 3 different areas of research: information systems, management, and educational research, and concluded that most of the definitions of this concept from the studies of information systems and management mention the goal of successful digital transformation, focusing on adjusted or new thinking, competencies, skills and behaviour of leaders.

So, digital leadership is a multifaceted concept and today there is no single approach to its interpretation, but it can be noted that the key aspects of digital leadership are: technology, strategy, innovation, culture, leadership skills, communication, personal development of the head and personal development of personnel, adaptation and openness to change, strategic partnership and, of course, cybersecurity.

1.1.2. Growing importance of digital leadership and ecosystem impact

In 2022, after the Covid-19 pandemic, many enterprises were determined to reach a new level through digital transformation, which would absorb all the processes in the company and allow them to gain new advantages thanks to digital technology, because the worst is over. However, in 2023, the plans are no longer so ambitious, because a full-scale russians invasion of Ukraine has entailed many negative consequences not only for Ukraine, and its economy but for the whole world. Among the main ones are economic uncertainty, inflation, and global recession. Businesses feel the effects directly or indirectly and this forces companies 'less satisfied' in terms of digital transformation and digital leadership.

Omar Akhtar (2023), interviewing 602 executives from various industries from North America, Europe, and Asia, created a report that charts the path for companies, which want to thrive in digital transformation. In this paper, 4 areas were allocated to which enterprises should focus during 2023 to improve the company's condition in the field of digitalization:

1) Skills and experience of employees: necessary constant attention to improving jobs, cooperation, and creating a digital culture that would promote autonomy and flexibility.
2) Data management and analytics: companies can get more out if they will use their customer's data for innovative products and better involvement of them, will it allow less reliance on data from tech giants like Google, Meta, etc.
3) Integration with market entry: instead of working separately, we will see more combined teams entering the market, as well as more business platforms that be able to attract customers throughout the life cycle.
4) Operational efficiency: enterprises need greater efficiency and speed of existing work processes, which indicates better cross-functional communication and more efficient data exchange between teams.

So, based on the above statements, we can conclude that in each of the 4 areas, attention is focused on employees: their skills, experience, level of cohesion, cooperation, and effective data exchange. Staff play a key role during the digital transformation, and therefore need digital leadership and an ecosystem that will allow you to organise and manage digital initiatives in the organisation in this way that employees can develop their digital skills, not fear change, collaborate on innovation, experimentation and use modern technologies to achieve the strategic goals of the organisation.

The importance of digital skills among the population is also emphasized by the European Union: after the signing of the European Declaration on Digital Rights and Principles, according to which people are at the centre of digital transformation. The political program of the European Union ‘Digital Decade’, contains specific goals and objectives until 2030 and at the same time directs the digital transformation of Europe in 4 areas: 1) skills – at least 80% of the population must possess basic digital skills, 2) digitalization of public services, 3) the availability of a secure and sustainable digital infrastructure, 4) digital

business transformation, which provides for that 75% of companies in the European Union use artificial intelligence, Big Data or Cloud, and more than 90% of small and medium-sized enterprises reach at least a basic level of digital intensity.

According to the study by the Ministry of Digital Transformation of Ukraine 'Digital Literacy Survey in Ukraine' (2023), 58.3% of adults see the relevance of digital skills training, and 85.0% of teenagers. Salaries of employees with digital skills are 81.3% higher than those without. 'The survey results also show that having advanced digital skills affects professional life satisfaction by an average of 17-29% compared to those who have not mastered digital skills. 68.5% of respondents with Above Basic Skills said that they were achieving their professional goals, while only 40.0% of respondents with No Skills agreed with this statement [difference of 28.5%]' (Ministry of Digital Transformation of Ukraine, 2023).

That is why digitalization and digital leadership are not only a matter of large companies that, for example, want to increase the efficiency of the organisation through the use of digital technologies, it is a matter of the present, which faces everyone, needs digital leaders and digital ecosystems not only in companies but also in everyday life. As noted by Cortellazzo, Bruni and Zampieri (2019), the leadership role has become crucial for realizing the real value of digitalization, but it is worth remembering that they are also partly responsible for solving ethical problems associated with digital transformation, such as information reboot of employees.

The Nash Squared team, in their 'Looking forward, looking back' (2023) digital leadership report, noted that in 2024, digital leaders will look for ways to do more with less. 'The 2023 Nash Squared Digital Leadership Report is the world's largest and longest-running survey of senior technology decision-makers…. This year a survey of 2,104 technology/digital leaders globally took place between 22 June 2023 and 18 September 2023, across 86 countries.' (Nash Squared, 2023, p 3).

As a result of the survey, the Nash Squared team identified the following among the main business priorities for technology: 1) improving work efficiency; 2) development of new products and services; 3) improving availability and customer interaction; 4) increasing the productivity of employees; 5) obtaining useful information from the data; 6) ensuring stable and consistent operation of IT; 7) improving flexibility and speed to market; 8) improving customer acquisition; 9) improving security and trust; 10) increased stability; 11) combating instability, risk and big changes; 12) entering new geographical markets; 13) improved employee engagement. The top priority in working with technology is still improving work efficiency, but 'two-thirds of our respondent's state that their CEO wants technology to 'make' rather than 'save' them money' (Nash Squared, 2023, p 14). This indicates that the priorities and tasks for the use of digital technologies are changing rapidly, and over the past 5 years have undergone significant changes. Therefore, the requirements for digital leaders and employees have changed and are changing, for example, more and more attention is paid to business skills, data, and customer experience, moving away purely from technical skills (Nash Squared, 2023). Digital leaders indicate that they are superior to competitors – Figure 1.

Figure 1. Directions where digital leaders are outperforming the competition

Source: Nash Squared (2023, p.16).

So, digital leaders are ahead of competitors in adopting new technology by 8%, customer experience by 2%, attracting & retaining new talent by 7%, and operational efficiency by 4%. They have the greatest advantage in the application of new technologies and attracting & retaining new talent, which is quite an interesting result because it was believed that the top 2 advantages should include operational efficiency. It can be concluded that digital leadership provides not only technological and operational advantages over competitors, but also a human resource advantage, which may be based on the existence of a digital leadership ecosystem that encourages staff to develop, and this may be one of the factors in candidates' preference for a particular company as a place with opportunities for improvement and growth.

1.1.3. Key characteristics and competencies that digital leaders should have

As Akhtar noted (2023, p 26): 'People and processes are a higher investment priority than ever before……This indicates a shift in transformational priorities where executives have realized that it's less about the tools and more about the people who use them. Hence, we're seeing increasing investment in training employees on new technology, optimizing existing processes, and improving the employee experience.' 'Their leadership has become increasingly embedded and critical to the business – broadening their remit from functional, operational roles into something more strategic and collaborative' (Nash Squared, 2023, p 15). The role of a digital leader and their competencies are important for a company, but there is no single approach to defining the key characteristics and competencies that digital leaders should possess. As already mentioned, digital leadership may include aspects of transformational leadership depending on the needs of the company, staff, and the external environment.

The views of scholars on the necessary key characteristics and competencies required for a digital leader are presented in Table 2.

Table 2. Analysis and summary of key characteristics and competencies that digital leaders should have.

Osborn and Fukuzawa (2016)	**Sullivan (2017)**	**Promsri (2019, p 6)**	**Gouveia (2019, p 41)**	**Bray (2022)**
Strategic thinking, having a vision	Digital Vision	Vision		Vision and strategy
Open to cooperation, personal learning, and teaching		Collaboration	Be collaborative, be a learner	
Strong communication skills	Communication		Be in compliance	Communication
Traditional business acumen				
Inspire/Cultivate the Talent of workers			Be a talent promoter wherever possible	Talent Spotting
Customer focus		Understanding of customers	Be client side but with results	
Ability to develop the necessary talent				
Flexibility				
Openness to risk		Risk-taking		Risk-Taking
Initiative				
Market-aware, local knowledge				
Analytical skills				
Cross-cultural competence	Cultural Awareness		Be an ethics champion	
Adaptability, Agility	Adaptability	Agility		Adaptability
	Digital Literacy	Digital knowledge and literacy		Digital Literacy
	Advocacy		Be people-oriented, be with others (groups and communities)	
	Presence		Be in networks and stay connected	
	Self-Awareness			
			Be able to balance between technical and social issues	
			Be sustainable	
				Innovation

Source: Author's own elaboration.

The key characteristics and competencies of a digital leader identified by the authors often coincide or are similar in nature, but there are some distinctive features. Most of the researchers' works were written in different years, which allows us to observe a small part of the evolution of this topic. Osborn and Fukuzawa (2016) wrote at a time when digital leadership was just emerging, so some of the competencies and characteristics of a digital leader are similar to the traditional idea of a leader: traditional business acumen, initiative, market awareness, local knowledge, etc. The second period of evolution includes some of the same characteristics as the first period, but new ones have emerged:

digital literacy, advocacy – as a leader you set the tone for the rest of the organisation, presence – actively championing digital initiatives, and leading by example, self-awareness, being able to balance between technical and social issues (Sullivan, 2017; Promsri, 2019; Gouveia, 2019).

In the so-called third period, which continues to this day, the focus has shifted to a small number of key characteristics that are common to all digital leaders: vision and strategy, communication, talent spotting, risk-taking, adaptability, digital literacy, and innovation (Bray, 2022). However, even today, scientists hold different views on the competencies and key characteristics required of a digital leader, in my opinion, it mostly depends on the industry, market where the company operates, external and internal factors, digital strategy, tasks, job responsibilities, etc. In other words, the characteristics and competencies of a digital leader depend to some extent on the circumstances in which the person is, and thus they can vary.

As a result of the content analysis, Klein (2020) identified the characteristics of digital leadership in 3 groups: general characteristics of the mind, characteristics related to digital business, and characteristics related to social leadership (Figure 2).

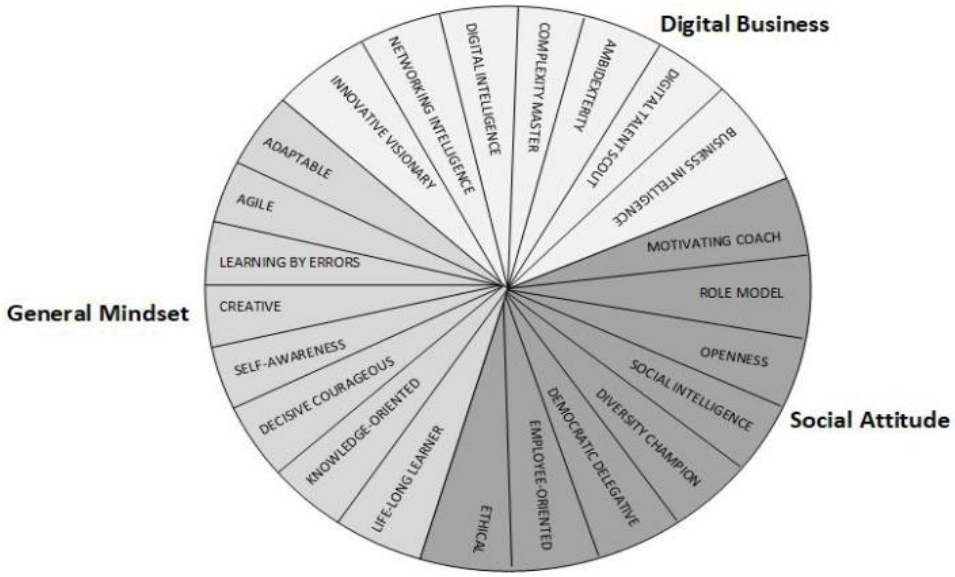

Figure 2. Digital Leadership Characteristics

Source: Klein (2020, p. 895)

Zhu (2015) described the style of a digital leader as creative, a thinker who is collaborative and has a global vision, he is a deep and exploratory leader. 'However, taking advantage of advancing technology requires courage, creativity, and cooperation. These are skills and capabilities that digital leaders have honed over years of leading change' (Nash Squared, 2023, p 15). Leaders cannot simply organise and 'manage' work in a digital environment; they must engage and inspire their employees to participate by removing personal limitations or insecurities, helping them define their role in the mission, and providing

the prospect of personal reward (George, 2018). O'Neill and Quinn (1993) pointed out that leaders need to behave and think holistically, using different, often even opposing leadership strategies. Weber, Krehl and Büttgen (2022) conducted thirty in-depth interviews with managers and employees, resulting in highlighted six leadership roles, each with a corresponding type of leadership behavior:

1) the digital pioneer – a leader who understands and assesses the risks and benefits of digitalization for business.
2) the innovator – a leader who is enthusiastic and inspires employees by inventing something new, he/she manages and implements changes based on innovative and creative ideas.
3) the enabler – active team members who facilitate joint decision-making, create flexible working conditions, a work environment that encourages employees to experiment, and support a culture of learning, trial, and error.
4) the mentor – a leader-manager who understands the individual strengths and weaknesses of his/her employees and seeks to establish strong and trusting relationships with employees, by providing them with individual support and mentoring.
5) the networker – a leader who strives to create an information network that would allow for quick collection and exchange of the necessary information, using many different sources.
6) the manager – a leader who does everything right, is task-oriented, and goal-oriented, closely monitors key performance indicators, and structures, and coordinates and controls work in a quality manner.

All these roles overlap and combine in the context of leadership, as each of them performs specific functions in the organisation and contributes to the achievement of goals. However, they differ in their characteristics and viewpoints: for example, the role of the innovator is more focused on operational aspects, while the role of the pioneer is more focused on strategic problem-solving.

Thus, a digital leader can combine several roles and possess even more competencies and key characteristics – only Promsi (2019) collected 64 characteristics of a digital leader in his review article, but it is important that, along with the use of digital technologies and strategies, he or she can effectively communicate, interact, develop a team, be flexible in problem-solving, could adapt to changes in a dynamic digital environment, promote positive transformations in the culture and strategic directions in the organisation, while creating an environment for innovation and effective implementation of digital initiatives. As George (2018) noted, instead of a position of power based on authority, a digital leader needs to pass the 'steering wheel' to others, choosing the right leader in each situation according to the circumstances. In other words, the team should have situational, competency-based, and sometimes self-organised leadership: senior executives are certainly important overall leaders, but subject matter experts and team leaders also play critical leadership roles. That's why it's important to create a hub of

innovation and development – an ecosystem where each member has a unique role and contribution that is aimed at achieving a common digital goal.

1.1.4. The concept of digital leadership ecosystem

‘A transformation can only flourish in an environment fostered for digital growth’ (Sullivan, 2017). The digital environment is important not only for successful digital transformation but also for the development of employees who can develop and improve the skills and abilities necessary for digital leaders. George (2018) pointed to the need to embrace the principle of 'people first'. Collaboration is one of the most important attributes of success for management and the company in the digital age, and it consists of two aspects: attitude and action. Employees need to be encouraged to develop the right attitude – they need to be willing to collaborate with at least their team members (George, 2018). The environment in which employees are located and the consequences of its influence on them depend on the manager-leader. ‘While that’s still the case for most companies (34%), it’s telling that for top-performing companies, it’s the CEO who’s likely to lead the transformation (33%). We’re increasingly seeing the involvement of top leadership as a key factor in a successful digital transformation. CEOs are well positioned to solve the biggest transformational challenges, including budget, culture, and strategic direction.’ (Akhtar, 2023, p 16). Therefore, it is senior management that shapes the culture, and ecosystem of digital leadership and points to its strategic vision in the organisation. Westerman et al (2011) pointed out that it is the holistic approach, the change of organisational structures, the integration of technology, and the culture of constant innovation that ensures the successful digital transformation of the company. It is the ecosystem of digital leadership that develops the digital culture of the organisation, allows you to rethink the methods of the company, and allows you to create and develop value in collaboration with various stakeholders. Araujo (2023) pointed out that we do not evolve in a vacuum, we are part of an ecosystem and what happens in this ecosystem has a direct impact on our daily work.

Sussan and Acs (2017) noted that a system is a group of organisations that interact and depend on each other, and function together as a whole to achieve a common goal, while an ecosystem is a network of interacting systems that are constantly changing and have a changing set of dependencies in a certain context.

Having conducted a systematic review of an array of studies about ecosystems Bogers, Sims and West proposed a new definition of an ecosystem as ‘an interdependent network of self-interested actors jointly creating value’ (2019, p 2). Adner defined the ecosystem as ‘the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize’ (2017, p 40). Thus, a system is usually made up of interacting components that need each other to function, so they exist together. An ecosystem, on the other hand, includes different components that may exist separately, but together they work to achieve a common goal or to maintain a common environment.

Li, Badr and Biennier defined the digital ecosystem as '…a self-organising, scalable and sustainable system composed of heterogeneous digital entities and their interrelations focusing on interactions among entities to increase system utility, gain benefits, and promote information sharing, inner and inter cooperation and system innovation' (2012, p 119). Valdez-De-Leon defined the digital ecosystem as 'loose networks of interacting organisation that are digitally connected and enabled by modularity, and that affect and are affected by each other's offerings' (2019, p 44). In my opinion, a digital ecosystem is not only about the interaction between organisations because it is also a set of interconnected components, such as people, processes, data, and technology, that interact within an organisation with the same goal of creating, implementing and/or optimizing digital products, services, or processes. Thus, a digital ecosystem is a set of interconnected components that includes both internal interactions between different departments or functional units within one organisation and external interaction between different organisations or companies to create, implement, and optimize digital products, services, or processes. Sussan and Acs (2017) noted that despite the differences in the views of scientists on the definition of the concept of a digital ecosystem, the commonality of all the various discussions points to two fundamental pillars of the digital ecosystem – people and digital technologies.

A leadership ecosystem is a set of interdependent departments or functional units in an organisation, other companies, and stakeholders that share common or similar values, approaches, strategies, methods, and actions used by different participants in this ecosystem to achieve common goals in developing and maintaining leadership. There are two main mechanisms of interaction in the leadership ecosystem: communication and cooperation – interaction between different levels of management, departments, and employees create a favorable atmosphere for the exchange of skills, ideas, and resources; training and development – providing opportunities for professional and personal development, training promotes the development of leadership skills among employees.

Integration of two ecosystems – leadership ecosystem and digital ecosystem – contributes to the creation of a digital leadership ecosystem – a new community where the integration of leadership ecosystems and digital technologies not only enhances their capabilities but also leads to the emergence of new opportunities that could not be achieved in isolation from each other. This ecosystem combines the advantages of leadership with the power and speed provided by digital technologies, creating unique opportunities for innovation, development, and achievement of set goals.

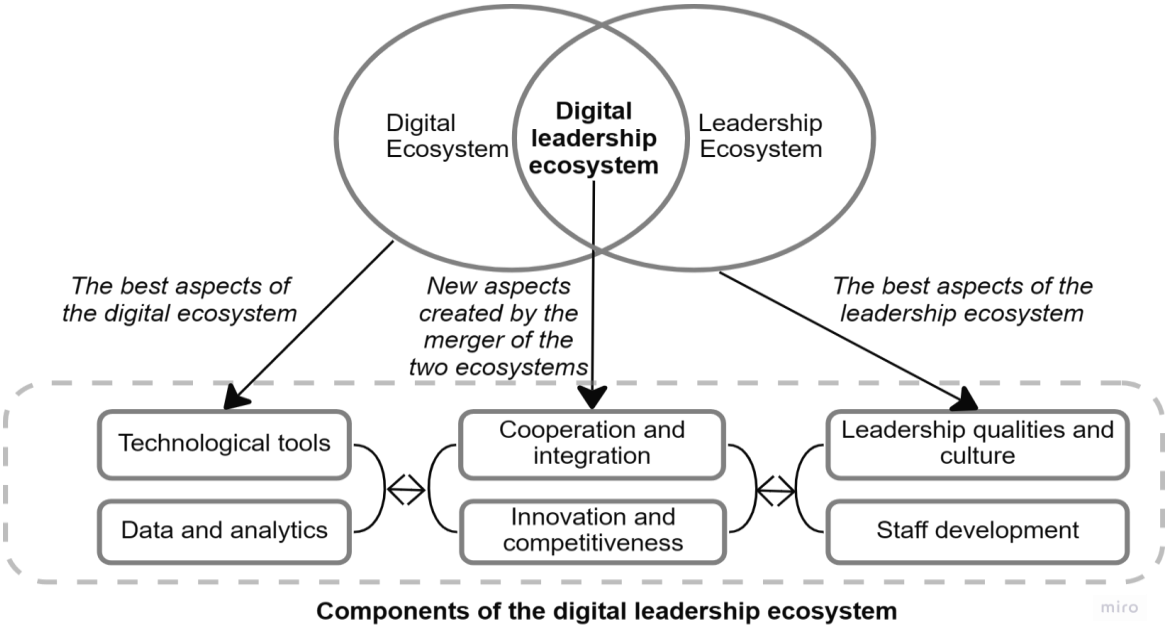

Figure 3. The digital leadership ecosystem and its components

Source: Author's elaboration

Therefore, the digital leadership ecosystem consists of both the leadership ecosystem and the digital ecosystem. Simultaneously, it incorporates the best aspects of these two systems, and their interaction generates new ones.

Components of the digital leadership ecosystem that are the best of the digital ecosystem: technological tools – the digital ecosystem provides access to a variety of technological tools, in particular such as cloud services, artificial intelligence, etc., that help in automating processes, improving work efficiency, developing and implementing innovative ideas and strategies; data and analytics – digital ecosystem provides access to a large amount of data, as well as tools for their use and analysis, this allows leaders to make informed decisions, predict trends and identify new development opportunities.

Components of the digital leadership ecosystem that are the best of the leadership ecosystem: leadership qualities and culture – the central element of the digital leadership ecosystem is the development of leadership qualities, such as initiative, responsibility for one's own decisions and actions, openness to risk, new ideas, etc., as well as creating a sense of belonging among managers and employees of the company; staff development – leadership ecosystem provides opportunities for staff training and development, including courses, training sessions, mentoring, etc., aimed at increasing career growth and personal development of managers and employees.

Components of the digital leadership ecosystem that were created as a result of the merger of two ecosystems: cooperation and integration – combining the components of the leadership ecosystem and the digital ecosystem creates unique opportunities, promotes cooperation and integration between

different groups and functional divisions of the company, contributes to strengthening the company's leadership position and achieving strategic goals; innovation and competitiveness – the synergy that arises from the interaction of two ecosystems, allows you to create and implement innovative solutions that help companies remain competitive, and possibly occupy leadership positions in a rapidly changing digital environment.

Thus, the digital leadership ecosystem combines the best aspects of both ecosystems, creating a unique environment and unique opportunities for the development and success of a company in the modern digital world.

Digital leadership ecosystems can be divided into three types depending on whether they involve external organisations or are based solely on an organisation's internal resources:

1) External digital leadership ecosystem – includes the interaction between the organisation/company and external stakeholders – other companies, partners, etc. This ecosystem is aimed at cooperation, co-development of innovations, joint problem solving, sharing of resources and data, as well as supporting digital promotion in a broad market context.

2) Internal digital leadership ecosystem – based on the internal processes, structures, and culture of the organisation itself, the ecosystem includes the interaction between internal departments, teams, projects, and initiatives aimed at ensuring digital advantage and innovation within the organisation itself.

3) Mixed digital leadership ecosystem – integration takes place between external and internal resources, processes, and strategies, the ecosystem includes both external and internal components, but they interact not only separately but also together to achieve digital leadership goals. It can include both joint projects and initiatives with external stakeholders, as well as internal processes aimed at supporting and using digital capabilities and technologies within the organisation.

Therefore, two types of digital leadership ecosystems: internal and external – can exist separately or coexist within the same digital leadership ecosystem, which contributes to the creation of a strong symbiosis between external and internal resources and contributes to the implementation of the company's strategic goals. The choice of the type of digital leadership ecosystem that will be formed in the organisation depends on its strategic plans, the nature of the business, financial and technical capabilities, etc.

Foss, Schmidt and Teece (2023) divided ecosystems into two types: mature ecosystems and emerging ecosystems, the so-called ‘new ecosystems’. Based on this study, an analogy was made with digital leadership ecosystems, which can also be mature (the one that has already been formed) or new, emerging (the one that is just forming). The main difference between these two types of digital leadership

ecosystems and the possible focus of leadership in these ecosystems was identified – the results are shown in Table 3.

Table 3. Mature digital leadership ecosystem vs. emerging digital leadership ecosystem

Mature digital leadership	Emerging digital leadership ecosystem
The main difference	
Stability	Instability, experimentation
High saturation of participants	Low saturation of participants
Established standards and rules	Search for 'optimal rules of the game'
Broad user base	Attracting the first users
A high level of value created	A low level of value created
Developed management mechanisms	Unformed management mechanisms
Interaction between participants is complex, due to the rules	Interaction between participants is more flexible, experimental
Defined leadership role	Leadership role less defined
Leadership is focused on	
Maintaining stability	Stimulating innovation
Developing new values	Establishing fundamental rules
Solving situational problems	Determining the direction of development
Process optimisation	Saving successful processes, changing and improving them
Development of new products/services	Finding a balance between stability and experimentation
Expanding market influence	Ecosystem development and expansion
Creating value for customers	Ensuring the viability of the ecosystem

Source: Author's own elaboration

Therefore, a mature digital leadership ecosystem and an emerging digital leadership ecosystem have significant differences, and thus require a different focus from that of digital leaders. In a mature ecosystem, there are already established rules and standards, a user base, there is a certain stability. The focus of the leader is mainly on maintaining this stability but at the same time improving work efficiency, developing new products or services, and expanding the company's influence on the market. In an emerging ecosystem or a new ecosystem, there are no established rules and standards – they are at the search stage, experiments are taking place and the first users are attracted. The focus of the leader is to establish fundamental rules, ensure the life of the ecosystem, balance between stability and experiments, determine the direction of development of the ecosystem and the company in this ecosystem, as well as stimulate innovation Therefore, while leading a new or emerging digital leadership ecosystem, it is important to drive innovation and experimentation, while when managing a mature digital leadership ecosystem, it is important to ensure stability and process optimization. However, in both cases, leaders should pay attention to ecosystem development, engagement of users, and value creation for them, as each digital leadership ecosystem is first and foremost individual and unique, and depends on the influence of many factors, sometimes even those that seem quite small and insignificant.

'When they work, ecosystems allow firms to create value that no single firm could create alone' (Adner, 2006, p 100). The ecosystem allows you to create new value that a company would not be able to create

on its own or would not be able to create within its enterprise without the right interaction of employees, teams, departments, and structures. However, it is difficult to assess the creation of this value in practice. Among the indicators of ecosystem success, researchers propose various options: customer satisfaction (Raja et al, 2013), market share (West & Mace, 2010; Adner & Kapoor, 2010), and experiments (Franke & Piller, 2004). In my opinion, the success of a digital leadership ecosystem can be measured using various indicators and metrics, depending on the strategy, goals, and objectives of the ecosystem. Among the possible ways of measuring are the following:

1) Increase in the number of customers or users interacting with the products and/or services provided in the ecosystem.
2) Level of customer or user satisfaction from the use of products or services in the ecosystem.
3) Assessment of the number and significance of innovations arising in the ecosystem.
4) Increasing the level of profitability in the ecosystem.
5) Volume and frequency of transactions – the number of online purchases of goods or orders for services, and data transfer between different systems, this indicator can indicate the activity of the digital leadership ecosystem and help assess its viability.
6) Interaction of participants and expansion of the digital leadership ecosystem – measuring the level of interaction between different participants in the digital leadership ecosystem, measuring the number of new participants, products, or services that are part of the ecosystem.

The digital leadership ecosystem is not about the achievements and uniqueness of one person who sets an unconditional example and ideas for others, it is about a joint process, a center of improvement, development, optimization, and innovation, where each team member plays their unique role and contributes to achieve a common goal and result. After all, there is no leader without a team.

1.2. Traditional leadership versus digital

1.2.1 Key characteristics of traditional and digital leadership

Leadership in company management is an important component, and effective leadership not only maximizes efficiency to achieve strategic goals but also manages employees, directing them to achieve their tasks. Erhan, Uzunbacak and Aydin pointed out that traditional leadership refers to an ‘approach that only considers the leaders and their functions by highlighting the concept as the sum of the leader’s performance in an organisation’ (2022, p 1525). Bass (1985) defined traditional leadership as a leadership style in which the leader uses his or her power and position in the company to control subordinates, solve problems in managing the organisation, and issue instructions. Traditional leadership is about authority and hierarchy, it is a typical leadership style where the leader is an authority

who gives instructions, monitors their implementation, and solves problems and tasks. ‘However, the role of leadership requires new capabilities to obtain a secure sustainability for the organisations, as the technological progress introduces many changes to the organisations, such as digitalization of work and the workplace.’ (Erhan, Uzunbacak & Aydin, 2022, p 1524). Eberl and Drews (2021) noted that digital leadership is a complex construct that primarily aims to create an advanced, digitally enabled, customer-centric business model, which can be achieved through the transformational role, style, and skills of a digital leader, the realizations of a digital organisation, and the adjustment of people management, communication, collaboration, knowledge and skills at the individual level. However, this does not mean that digital leadership is as different as possible from traditional leadership, on the contrary, digital leadership combines traditional leadership skills, abilities and with new ones necessary for the effective management of an organisation in the modern digital world.

Rizvi (2022) pointed out that digital leadership is a term that describes the use of digital technologies by leaders to communicate with and motivate employees, digital leadership allows leaders to better communicate with their employees even if they are in different geographical locations. Digital leadership can help create a more cohesive work environment by enabling employees to collaborate and communicate more easily, whereas traditional leadership requires direct proximity between the leader and employees, which in turn requires more effort and time on the part of the leader to maintain an appropriate level of relationship with employees.

Table 4. Traditional leadership vs Digital leadership

Traditional leadership	Digital leadership
The key differences	
It has been around for centuries	New and emerging sphere
Low inclination to risk, change, and uncertainty	High inclination to risk, change, and uncertainty
Use traditional means of communication and cooperation, formal means of communication	They tend to collaborate more by using social media and other digital tools
Usually focused on preserving the status quo, effective management of current tasks and resources, conservative in their approaches	Focused on the future, using technology to drive innovation and growth
Advantages	
Building relationships and trust: face-to-face contact can help you better understand each team member's capabilities, needs, and motivations	Digital leaders are better prepared to lead in today's digital world: they are comfortable with technology and know how to use it to their advantage
Faster response to unusual situations due to personal contact as an effective way of cooperation and communication	Are more joint: digital leaders are more likely to use social media and other digital tools to interact with their employees and customers to get feedback
Can provide better opportunities to identify and develop the leadership skills of team members through personal contact, observation, and learning in real-life situations	More flexible, as it is not tied to outdated systems and processes, and can quickly adapt to changes in the market and within the organisation

Table 4 (Continued)

Traditional leadership	Digital leadership
Situations where this type of leadership is preferable to another	
When there is a need for a clear chain of command, it eliminates the attempts of everyone to take responsibility, as there is a clear hierarchy and division of responsibilities	Adaptability to a rapidly changing digital world, where leaders must be able to quickly adapt their plans and strategies to stay ahead of the curve
Crises and the need to take quick and decisive action, allow you to quickly organise a team and ensure that each team member understands the purpose and level of responsibility through personal contact and communication	Openness to new ideas, perspectives, and readiness to embrace change: digital leaders foster collaboration and innovation within the team, which contributes to engaging different prospects and enhancing creativity
An environment where change is not constant and fast because in this case, digital leadership can hinder the process	Transparency and openness in decision-making, contribute to increasing the trust and involvement of employees in a common goal. Digital leaders are open to dialogue with the team, want the team to understand their rationale, and provide feedback

Source: Author's own elaboration, based on Rizvi (2022)

Therefore, both digital and traditional digital leadership have their advantages and disadvantages, and both approaches can be effective in different situations. Traditional leadership emphasizes face-to-face contact, relationship building, and achieving efficiency in a standard environment, while digital leadership simplifies communication, collaboration, and adaptation to a rapidly changing environment. The main principle is to choose an approach that meets the specific needs of the organisation and the team, their characteristics, and goals, and if necessary, it can even be a combination of both of these styles.

2. Research Methodology

2.1. Objective of the Study and Research Hypotheses

The purpose of this study was to determine the impact of the digital leadership ecosystem on changing management profiles in companies located and operating in the Volyn region of Ukraine. The study is aimed at revealing the mechanisms and consequences of this influence, forming new leadership qualities and competencies in managers, or improving existing ones.

To confirm the purpose of this study, five hypotheses were formed:

1) The results of the study can be trusted because the sample comes from a normally distributed population.
2) As the digital competence of executives grows, so will their digital leadership and vice versa.
3) The digital strategy considers the digital risks of the organisation's ecosystem and vice versa.
4) Increasing the level of adaptability and flexibility of a manager leads to an increase in his/her self-awareness, gender equality, cultural and religious awareness, and vice versa.
5) There is a statistically significant relationship between the gender of the respondents and the use of digital strategy.

These hypotheses contributed to an in-depth analysis of the impact of the digital leadership ecosystem on both the managerial profiles of executives and the company. They helped to identify key aspects of this impact and considered the various consequences after the implementation of the digital leadership ecosystem.

2.2. Description of Data Collection

The instrument used to collect data in this study on the impact of the digital leadership ecosystem on managerial profiles is a structured questionnaire designed to elicit comprehensive feedback from participants.

The questionnaire consisted of two parts:

1) A survey in Google form, which required the respondents to fill in the form:
    a) Section 1. Filling in personal information, such as name, company's field of activity, position, number of employees in the company at the moment, and age.
    b) Section 2. Evaluation of the proposed statements on a scale from 1 to 5, where: 1 (very low); 2 (low); 3 (neutral); 4 (high); 5 (very high). This part involved determining the level of influence

of the digital leadership ecosystem by: assessing the level of digitalisation in the company, the leader's own digital skills at the time of the survey, the level of compliance with the characteristics inherent in the digital leadership ecosystem, indicating the skills and personal qualities that the leader needed to build or improve and effectively manage the digital leadership ecosystem.

2) Online interviews in the format of open-ended questions, respondents were asked to:

   a) Describe the current state of the digital leadership ecosystem in the company: its essence, challenges in the process of formation and adaptation, benefits provided by its implementation.

   b) Evaluate the impact of the digital leadership ecosystem on personal qualities, skills, management practices, and interaction between them (the leader) and their team/subordinates, between employees.

   c) Share experience on the impact of the company's corporate culture on the implementation of digital initiatives, steps taken by the organisation to develop digital skills of staff and management, digital strategy, and competitive advantages in the market.

The data collection process lasted for one month. During this time, participants were sent requests to agree on a date for an online interview and were asked to complete the survey in a Google form. The average duration of the online interview was 25 minutes. An example of the questionnaire can be found in Appendix A.

Overall, the questionnaire was not only a convenient tool for data collection, but also a powerful source for gathering insights into the perceptions, practices, and impacts of the digital leadership ecosystem among managers. Its results allowed us not only to assess the impact of the digital leadership ecosystem on managerial profiles but also to analyze its various aspects. They allowed revealing the connections between leadership and digital tools.

2.3. Description of Data Analysis

In this study, we used a combination of open-ended questions and a data collection questionnaire. Open-ended questions allowed respondents to express their opinions, beliefs, and experiences about the research topic freely, without restrictions. This allowed us to gain a deeper understanding of their thoughts and beliefs.

To begin with, a descriptive analysis was conducted, which made it possible to get an overall picture of the answers to both open questions and questions that were contained in the questionnaire, using: pivot tables, pie charts, and histograms. The results of the analysis indicate a significant variety of views and

opinions among respondents on the issues under consideration, which further emphasizes the versatility of their beliefs and experiences.

Also, an inference analysis was performed to identify connections and determine statistically significant differences in the groups of managers, testing hypotheses. To test the first hypothesis, the Pearson consent criterion was used, for the second, third, and fourth, the Mann-Whitney criterion. The latter hypothesis was tested based on the contingent coefficient. The data necessary to prove the first and fifth hypotheses were provided during the study, and to prove the second, third, and fourth hypotheses – in Appendix B.

The conducted data analysis confirmed the accordance of the obtained results with the initial research objective. In addition, logical conclusions were formulated based on the analysis, which contributed to a deeper understanding of the impact of the digital leadership ecosystem on managerial profiles.

2.4. Population *vs.* Sample

In this study, the population covered the heads of companies in the Volyn region of Ukraine, which introduced or developed the ecosystem of digital leadership. This group included executives from various industries who held various management positions in small, medium, or large companies, but all of them were consistent with the target audience of the study. Respondents had different levels of competence and experience in the field of digital management.

For this study, a random sample was selected from the set of heads of companies in the Volyn region of Ukraine. The criteria for inclusion in the sample included a manager who has some experience in digital management and can provide objective answers to the research questions. Each respondent had a certain level of experience in digital governance, which ensured the quality and reliability of the information provided.

This study was to a greater extent aimed at collecting, analyzing, and interpreting non-numerical data to understand and gain an in-depth understanding of the impact of the digital leadership ecosystem on changing management profiles.

That is, the method of this work was a qualitative study, which involved conducting online interviews in the format of open questions with company leaders. This needed considerable time to conduct and analyze. Therefore, a sample size was established at a confidence level of 85% (Z) and an error of 16% (E). The sample size was calculated by the formula for calculating the sample size for proportions – Eq.1.

$$n = \frac{Z^2 \times p \times (1-p)}{E^2} \quad [1]$$

where n – is the sample size, Z – is the critical value of the standard distribution for the specified level of confidence (in our case, it is - 85%). The value of ‘Z’ was taken from the Table of the Standard Normal

Distribution corresponding to the 85% confidence level, it was 1.440. p – sample proportion (or population proportion estimate). It was assumed to be 0.5 because we had no prior data, and the value of 0.5 provided maximum variability (uncertainty). This cautious approach ensured that the sample was large enough for any realistically possible proportion. E – allowable error, was set at 16%.

The calculation of the sample size is given in Eq. 2.

$$n = \frac{1.440^2 \times 0.5 \times (1 - 0.5)}{0.16^2} = \frac{2.0736 \times 0.25}{0.0256} = \frac{0.5184}{0.0256} = 20.25 \quad [2]$$

3. Presentation and Analysis of Results (Empirical Results Analysis)

3.1. Sample Characterisation/Profile

This survey involved 20 managers who worked in various fields. When filling out the Google form, respondents answered questions that allowed us to briefly describe their profile. The results of the survey are shown in Table 5.

Table 5. Characteristics of the respondents

Respon-dent (R)	Job position	Gender	Age	Number of employees currently working in the company
R #1	Director	Male	36-45	10
R # 2	Manager/Head	Male	36-45	650
R # 3	Senior Specialist in the International Relations Department	Female	36-45	Over 500
R # 4	Chief	Female	36-45	150
R # 5	Head of Marketing Department	Male	26-35	50
R # 6	Director	Female	46-55	60
R # 7	Director	Male	36-45	25
R # 8	Head of HR	Female	36-45	70
R # 9	Technical Director	Male	26-35	27
R # 10	Vice Director	Female	26-35	36
R # 11	Individual Entrepreneur	Male	19-25	7
R # 12	Head of Specialists	Male	19-25	5000
R # 13	Product Manager, Head of Product Department	Female	26-35	120
R # 14	Senior Curator of the History Department	Female	36-45	Near 120
R # 15	Head of Sales Department	Female	19-25	11
R # 16	Head of Service Department	Female	36-45	60
R # 17	Director	Female	46-55	90
R # 18	IT-director	Male	36-45	5
R # 19	Chairperson of the Management Department	Female	36-45	Over 900
R # 20	Dean of the Business Faculty	Female	36-45	Near 950

To confirm that the results of the study can be trusted, and the data are suitable for further analysis, the first hypothesis was formed:

Null hypothesis (H_0): The sample was drawn from a normally distributed population, and the results of the study can be trusted.

Alternative hypothesis (H_1): The sample wasn't drawn from a normally distributed population, and the results of the study can't be trusted.

The hypothesis that the sample (X) was distributed according to a normal law was tested based on Pearson's test of agreement – Eq. 3.

$$K = \sum \frac{\left(f_i - f_i^{thcor}\right)^2}{f_i^{thcor}} \quad [3]$$

where K – coefficient of contingency. This measure indicates how much the observed frequencies differ from those expected, considering the independence between variables. The higher the value of K, the stronger the dependency between the variables. f_i- observed frequency in the i-th contingency table cell. f_i^{thcor} - expected frequency in the i-th cell under the assumption of independence between variables – Eq. 4.

$$f_i^{thcor} = \frac{N \times h}{\sigma} \times \Phi_i \quad [4]$$

Where N – total number of observations in the sample, h – width of the interval, σ – mean square deviation, Φ_i – probability of event i.

The initial data required for calculating the theoretical frequencies are provided in Table 6.

Table 6. Initial data for calculating theoretical frequencies.

x_i	f_i
25	3
35	4
45	11
55	2
∑	20

where x_i – this is a representative value for each interval.

The theoretical frequencies were calculated, considering that the interval width (h) was equal to 10, the weighted/sample average (x_{cr}) – 41 (Eq 5), and mean square deviation (σ) – 8.602 (Eq 6, Eq 7).

$$x_{cr} = \frac{\sum x_i \times f_i}{\sum f_i} = \frac{25 \times 3 + 35 \times 4 + 11 \times 45 + 55 \times 2}{3 + 4 + 11 + 2} = \frac{75 + 140 + 495 + 110}{20} = \frac{820}{20} = 41 \quad [5]$$

$$\sigma = \sqrt{D} = \sqrt{\frac{\sum (x_i - x_{cr})^2 \times f_i}{\sum f_i}} \quad [6]$$

$$\sigma = \sqrt{\frac{((-16)^2 \times 3 + (-6)^2 \times 4 + 4^2 \times 11 + 14^2 \times 2)}{3 + 4 + 11 + 2}} = \sqrt{\frac{768 + 144 + 176 + 392}{20}} = \sqrt{74} = 8.602 \quad [7]$$

The frequency expected in the i-th cell was calculated, provided there is no dependence between the variables based on Eq. 8. The results of the calculations are provided in Table 7.

$$f_i^{thcor} = \frac{20 \times 10}{8.602} \times \Phi_i = 23.25\Phi_i \quad [8]$$

Table 7. Calculation of the frequency under the condition that there is no dependence between the variables.

i	x_i	$u_i ((x_i - x_{cr}) / \sigma)$	Φ_i	f_i^{thcor}
1	25	-1.86	0,0707	1.644
2	35	-0.6975	0,3123	7.261
3	45	0.465	0,3572	8.305
4	55	1.6275	0,1057	2.457

Where u_i – is the standardized value x_i, which was calculated by subtracting the mean of the interval (x_i) to the average value of all dat (x_{cr}). The obtained result was divided by the mean square deviation (σ). Φ_i – are the probabilities that correspond to the standardized values u_i. These probabilities were taken from a standard normal distribution table.

The next step was to compare the theoretical frequencies (the numbers we expected to see in the sample) and the empirical frequencies (the numbers we observed). A calculation table was created – Table 8, to calculate the x^2-statistic in the Pearson agreement test based on Eq. 9.

$$x^2 = \sum \frac{\left(f_i - f_i^{thcor}\right)^2}{f_i^{thcor}} \quad [9]$$

Table 8. Calculation of the x^2-statistic in the Pearson agreement criterion.

i	f_i	f_i^{thcor}	$f_i - f_i^{thcor}$	$(f_i - f_i^{thcor})^2$	$(f_i - f_i^{thcor})^2 / f_i^{thcor}$
1	3	1.6437	-1.3563	1.8394	1.119
2	4	7.2608	3.2608	10.633	1.464
3	11	8.3047	-2.6953	7.2645	0.875
4	2	2.4575	0.4575	0.2093	0.0852
∑	20	20			3.543

The boundary of the critical area was determined. Since Pearson's statistics measure the difference between empirical and theoretical distributions, the greater its observed Knabl value, the stronger the argument against the main hypothesis. Therefore, the critical area for this statistics is always right-hand: $[K_{kp};+\infty)$. The boundary of the observed limit of the Pearson statistic (K_{kp}) was calculated based on Eq. 10.

$$K_{kp} = x^2_{\alpha;df} \quad [10]$$

where α – level of significance (the probability of rejecting the null hypothesis if it is true). By default, α is 0.05. df – degrees of freedom. It was calculated in Eq. 11.

$$df = k - r - 1 = 4 - 2 - 1 = 1 \quad [11]$$

Where k – is the number of categories or intervals into which the data has been broken down. In this study, observations were divided into 4 parts or groups. r – the number of parameters estimated by the sample. In this study, these were the weighted/sample average and mean square deviation which were calculated from the data of the sample. Thus, the number of parameters estimated by the sample was equal to 2 (the parameters x_{cp} and σ were assessed from the sample).

As follows, the boundary of the Pearson statistic (K_{kp}) was equal to α = 0.05 and df = 1 – K_{kp} (0.05;1). The critical value for the significance level α = 0.05 and df (degrees of freedom) = 1 was taken from the tables of critical distribution values x^2. It was equal to 3.841 (K_{kp} (0.05; 1) = 3.841). The observed value of the criterion that described the square of a standard normally distributed values ($K_{nabl} = x^2$) was equal to 3.54. The observed value of the Pearson statistic didn't fall into the critical region: $K_{nabl} < K_{kp}$, therefore, there wasn't reason to reject the main hypothesis. The assumption that these samples have a normal distribution was true.

The respondents during the survey indicated the type of economic activity of the company, which created the necessary context for understanding the specifics of management in a particular industry, and allowed identifying the features that influence management decision-making, the formation and development of the digital leadership ecosystem. The research of this influence in the context of a specific sector of the economy has helped to identify the unique challenges and opportunities faced by managers. Figure 4 shows the number of surveyed executives working in the respective economic sector.

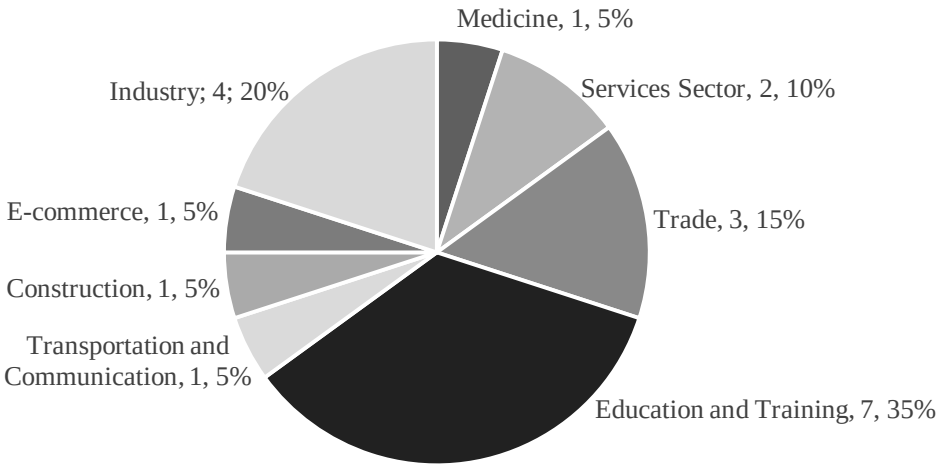

Figure 4. The structure of companies' activities among surveyed managers

3.2. Respondent's digital skills and the level of digitization in their organisations

The level of digitalization in a company is an important factor for successful operation in the modern world, as it increases the company's competitiveness, automates routine tasks, thereby increasing productivity and reducing time and resource costs, and opens new development opportunities, such as creating new products or optimizing customer interaction processes. In the context of the ecosystem of digital leadership, this has an additional meaning: a high level of digitalization in the company allows you to create more development innovative products, respond more quickly to changes in the technological environment, create a favourable environment for the development of digital leaders, also attract talented specialists because it provides an opportunity to work and evolve with advanced technologies. The results of the respondent's assessment of the current level of digitalization in their companies were based on a 5-point scale, where a score of 1 indicates a very low level of digitalization in the organisation, and 5 - is a very high level. Figure 5 shows the overall level of digitalization of companies, and Figure 6 shows the average level of digitalization of companies according to the economic sector of organisations.

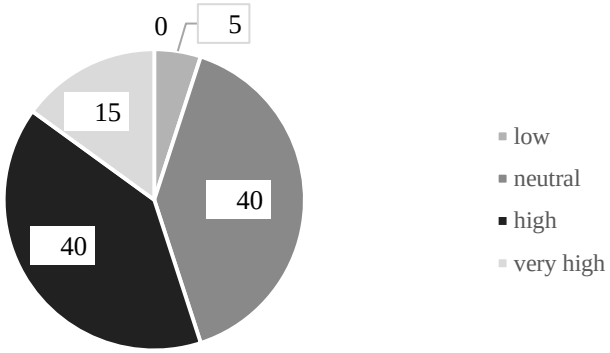

Figure 5. The level of digitalization in the companies where the respondents work

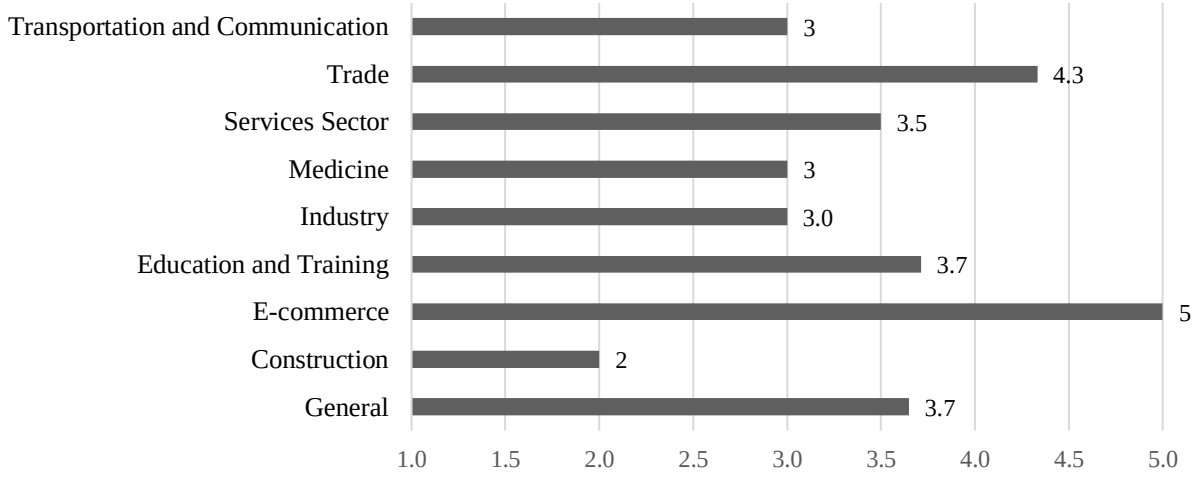

Figure 6. The average level of a company's digitization across economic sectors

As part of the survey, respondents conducted a self-assessment of their digital skills. They were asked six questions and evaluation was conducted by the same rating scale that was used to assess the level of digitalization in their companies. The self-assessment included an assessment of the level of digital vision, digital competence, digital leadership, own adaptability and flexibility, digital safety, and cyber security, as well as understanding one's impact on the digital environment in the team and the formation of a corporate culture that provides equal digital opportunities regardless of gender, religious or cultural differences. Respondents had the opportunity to rate their skills from very low level to very high. This process allowed us to get an idea of the current level of digital literacy in a sample group of managers participating in the study. The respondents' assessment of their digital skills is shown in Figure 7, and the average level of assessment of the digital skills of the interviewed managers is shown in Figure 8.

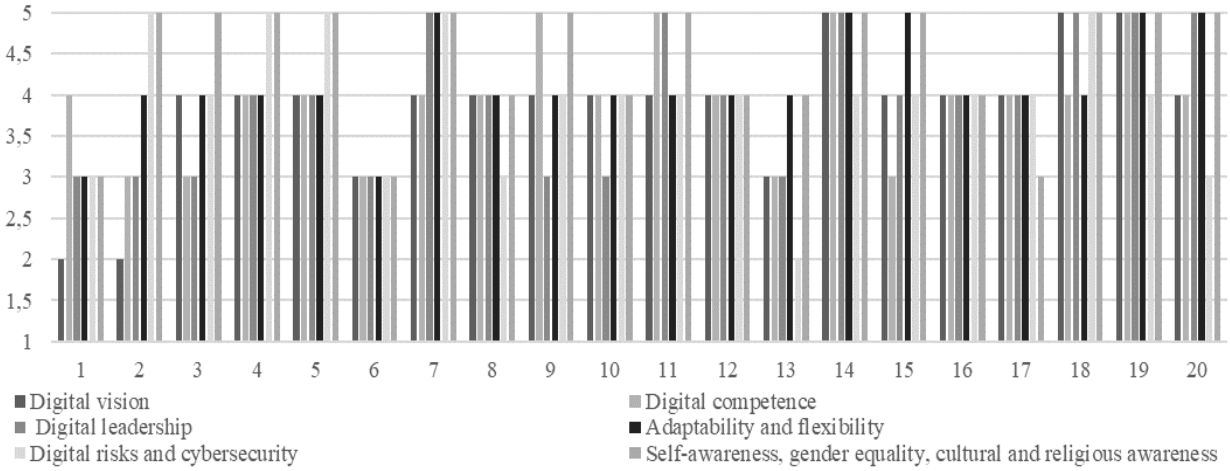

Figure 7. Respondents' assessment of their digital skills

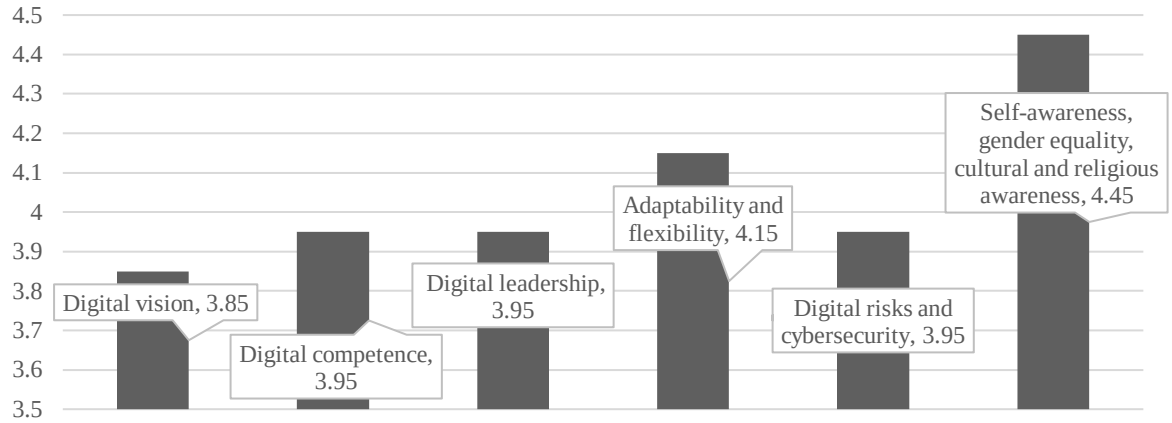

Figure 8. Average assessment of digital skills of respondents

The next stage was the study of the relationship between the digital competence of managers and the level of their digital leadership. For this, a second study hypothesis was put forward:

Null hypothesis (H_0): The level of the sign in the response group – digital leadership wasn't lower than the level of the characteristic in the group – digital competence.

Alternative hypothesis (H_1): The level of the sign in the response group – digital leadership was lower than the level of the characteristic in the group – digital competence.

The hypothesis was supported by the Mann-Whitney criterion – Eq. 12.

$$U_{emp} = n_1 \times n_2 + \frac{n_x \times (n_x + 1)}{2} - T_x \quad [12]$$

Where U_{emp} – this is the empirical value of U (the statistic used to compare two independent samples based on their ranks), obtained as a result of calculations from the sample data. T_x – the largest sum of ranks, n_x – the largest of the volumes of selection n_1 and n_2.

The comparison in Table 10 showed that the value of the choice of X_{DC} (digital competence) was higher than that of the choice of Y_{DL} (digital leadership), therefore, the choice of X_{DC} was considered the first. The goal was to determine whether the difference between scores could be considered significant.

The first stage was ranking the table. When ranking, two samples were combined into one. Ranks were assigned in order of increasing value of the measured value, that is, the lowest rank corresponded to the lowest score. In the case of coincidence of rank for several respondents, the rank of such a score was considered the arithmetic mean of their positions occupied by these scores when they were arranged in ascending order.

Since there were related ranks (the same rank number) of the 1st row in the matrix, their reformation was done. Reshaping of ranks was carried out without changing the importance of the rank, i.e., the corresponding ratios – greater, less, or equal – had to be preserved between the rank numbers. The rank was not set above 1 and below a value equal to the number of parameters (40). The transformation of ranks is given in the Table 9.

Table 9. Rank transformation (digital competence, digital leadership)

Numbers of places in the ordered sequence	Position of factors in the respondent's (expert's) assessment	New ranks
1	3	6.5
2	3	6.5
3	3	6.5
4	3	6.5
5	3	6.5
6	3	6.5
7	3	6.5
8	3	6.5
9	3	6.5
10	3	6.5
11	3	6.5
12	3	6.5
13	4	21.5
14	4	21.5

Table 9 (continue)

Numbers of places in the ordered sequence	Position of factors in the respondent's (expert's) assessment	New ranks
15	4	21.5
16	4	21.5
17	4	21.5
18	4	21.5
19	4	21.5
20	4	21.5
21	4	21.5
22	4	21.5
23	4	21.5
24	4	21.5
25	4	21.5
26	4	21.5
27	4	21.5
28	4	21.5
29	4	21.5
30	4	21.5
31	5	35.5
32	5	35.5
33	5	35.5
34	5	35.5
35	5	35.5
36	5	35.5
37	5	35.5
38	5	35.5
39	5	35.5
40	5	35.5

Based on the expert's rating of '3', the process of leveling the ranking results took place as follows:

1) It was determined in which positions the related values are located (in this case, the value ‘3’): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.

2) The mean rank for these positions was determined based on Eq. 13.

$$MR = \frac{1+2+3+4+5+6+7+8+9+10+11+12}{12} = \frac{78}{12} = 6.5 \quad [13]$$

Thus, each value of '3' was assigned a rank of '6.5'. Assigning ranks to other values was done in the same way. The ranking results for the selection value of X_{DC} (digital competence) and Y_{DL} (digital leadership) are shown in Table 10.

Table 10. Ranking results for the value of choice X_{DC} (digital competence) and Y_{DL} (digital leadership)

X_{DC} (digital competence)	Rank X_{DC}	Y_{DL} (digital leadership)	Rank Y_{DL}
3	6.5	3	6.5
3	6.5	3	6.5
3	6.5	3	6.5
3	6.5	3	6.5
3	6.5	3	6.5
4	21.5	3	6.5
4	21.5	3	6.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	4	21.5
4	21.5	6	35.5
4	21.5	6	35.5
5	35.5	6	35.5
5	35.5	6	35.5
5	35.5	6	35.5
5	35.5	6	35.5
Sum	411	Sum	409

These data were sufficient to use the formula calculating the empirical value of the criterion – the Mann-Whitney criterion. The calculation results are shown in Eq. 14.

$$U_{emp1} = 20 \times 20 + 20 \times \frac{20+1}{2} - 411 = 199 \quad [14]$$

The hypothesis H_0 about the insignificant difference between the samples was accepted only if $U_{cr}<U_{emp}$. Otherwise, the H_0 hypothesis was rejected and the difference between the sample scores was considered significant.

U_{cr} – is a critical point used to decide on the statistical significance of the difference between two samples in the Mann-Whitney test.

From the table of critical values for the Mann-Whitney test, the values of the critical point (U_{cr}) for significance levels (α) 0.05 and 0.01 were found: $U_{cr}(0.05) = 127$; $U_{cr}(0.01) = 105$.

Since $U_{cr}<U_{emp1}$ the null hypothesis (H_0) was accepted with a probability of 95% – the difference in samples levels could be considered not significant. As the digital competence of executives grows, so will their level of digital leadership and vice versa.

The third hypothesis of the study: 'The digital strategy considers the digital risks of the organisation's ecosystem and vice versa', was tested using the Mann-Whitney criterion – Eq. 12. For this purpose, null and alternative hypotheses were formulated:

Null hypothesis (H_0): The level of digital vision of managers wasn't lower than their level of signs in the group – digital risks and cybersecurity.

Alternative hypothesis (H_1): The level of digital vision of managers was lower than their level of signs in the group – digital risks and cybersecurity.

The process of leveling the ranking results for hypothesis #2 followed similarly to the process of leveling the ranking results that were applied to confirm the second hypothesis. The confirmation of hypothesis #3 showen in Appendix C. We got the result U_{emp2} – 189.5.

The hypothesis H_0 about the insignificant difference between the samples was accepted only if $U_{cr}<U_{emp}$. Otherwise, the H_0 hypothesis was rejected and the difference between the sample scores was considered significant.

From the table of critical values for the Mann-Whitney test, the values of the critical point (U_{cr}) for significance levels (α) 0.05 and 0.01 were found: $U_{cr}(0.05) = 127$; $U_{cr}(0.01) = 105$.

Since $U_{cr}<U_{emp2}$ the null hypothesis (H_0 was accepted with a probability of 95% – the difference in samples levels could be considered not significant. The digital strategy considers the digital risks of the organisation's ecosystem and vice versa.

During the survey, respondents evaluated their level of two digital skills – adaptability and flexibility, self-awareness, gender equality, cultural, and religious awareness. Based on these results, the fourth research hypothesis was formed:

Null hypothesis (H_0): The level of adaptability and flexibility of managers wasn't lower than their level of signs in the group – self-awareness, gender equality, cultural and religious awareness.

Alternative hypothesis (H_1): The level of adaptability and flexibility of managers was lower than their level of signs in the group – self-awareness, gender equality, cultural and religious awareness.

The hypothesis was tested for reliability using the Mann-Whitney test – Eq. 12.

The process of leveling the ranking results followed similarly to the process of leveling the ranking results that were applied to confirm the second and third hypothesis. The confirmation of hypothesis #4 showen in Appendix D. We got the result U_{emp3} – 144.

The hypothesis H_0 about the insignificant difference between the samples was accepted only if $U_{cr}<U_{emp}$. Otherwise, the H_0 hypothesis was rejected and the difference between the sample scores was considered significant.

From the table of critical values for the Mann-Whitney test, the values of the critical point (U_{cr}) for significance levels (α) 0.05 and 0.01 were found: $U_{cr}(0.05) = 127$; $U_{cr}(0.01) = 105$.

Since $U_{cr}<U_{emp3}$ the null hypothesis (H_0) was accepted with a probability of 95% – the difference in samples levels could be considered not significant. Increasing the level of adaptability and flexibility of a

manager leads to an increase in his/her self-awareness, gender equality, cultural and religious awareness, and vice versa.

The data required to test the hypothesis #2; #3; #4 – are provided in Appendix B.

Although the digital leadership ecosystem and digital leadership are considered relatively new concepts, some organisations have already managed to develop this ecosystem during the implementation of digital transformation. Based on the responses of surveyed managers, it was investigated what new skills and personal qualities were needed by managers to build a digital leadership ecosystem, the results are shown in Figure 9. The skills and personal qualities that were necessary to manage and improve the existing ecosystem of digital leadership were also identified. Of the twenty respondents surveyed, there were only 4 such answers. Each of these answers contained only one personal quality/skill, but the answers didn't match. The results are shown in Figure 10.

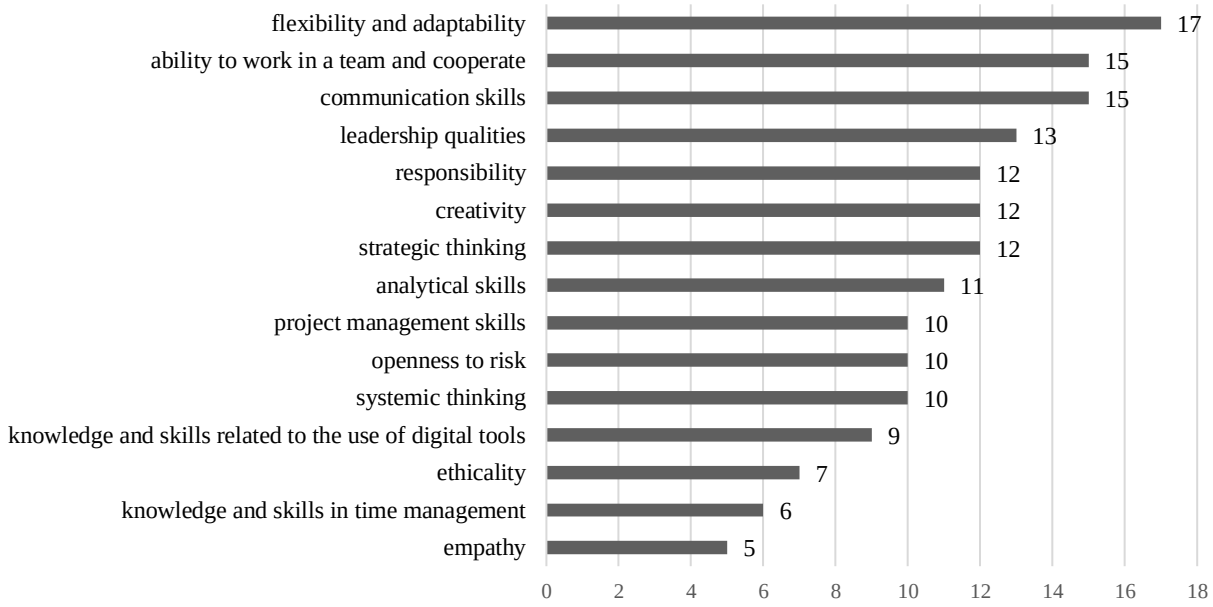

Figure 9. Rating of new skills and personal qualities required by respondents to build a digital leadership ecosystem in their organisations.

Figure 10. Skills that respondents needed to effectively manage and improve the digital leadership ecosystem.

The next stage of the research was to assess the level of transition from the traditional approach to digital leadership in the respondents' companies. Digital leadership is a key element needed to build and sustain a digital leadership ecosystem, as digital leaders often involve other members, creating networks of collaboration and sharing of ideas that help build a pool of talent capable of innovation and adoption of new technologies. The assessment was based on a survey of respondents regarding adherence to certain statements that characterized the transition from a traditional approach to digital leadership. Adherence to statements was assessed on a 5-point scale, where 1 is a very low level and 5 is a very high level. The general results of the survey are shown in Figure 11.

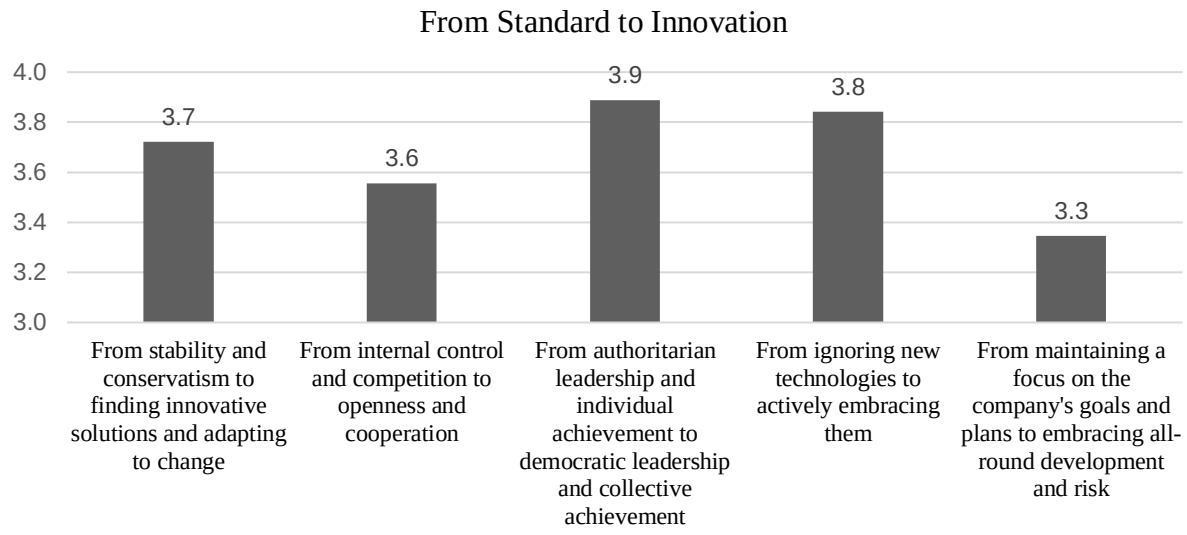

Figure 11. Assessment of management change implementation: Journey from standard to innovation

The final stage of the survey in the Google form was the respondents' choice of the type of digital leadership ecosystem that operates in their organisation. There were three options among the possible answers: 1) external type of digital leadership ecosystem – the company interacts with external stakeholders, and the ecosystem is focused on co-developing innovations, exchanging resources and data, as well as supporting digital advancement; 2) internal – grounded in internal processes, structures, and culture of the organisation itself, the ecosystem involves interactions between internal departments, teams, projects, and initiatives aimed at ensuring digital advantage and innovation within the organisation; 3) mixed (combines external and internal aspects) – integration of external and internal resources, processes, and strategies occurs, the ecosystem includes both external and internal components that interact not only separately but also collectively to achieve digital leadership goals. It may include joint projects, initiatives with external stakeholders, as well as internal processes aimed at supporting and utilizing digital opportunities and technologies within the organisation. The results of the answers of the surveyed managers are shown in Figure 12.

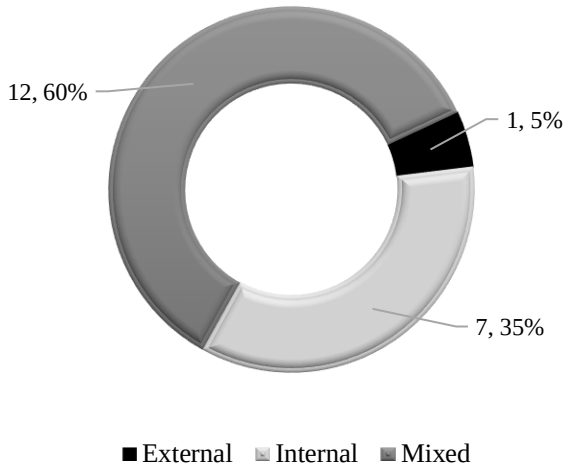

Figure 12. The type of digital leadership ecosystem operating in the respondents' companies

3.3. Impact of the digital leadership ecosystem

In this and the following parts of the work, the open questions answered by the respondents during the online interview were analyzed.

3.3.1. Digital leadership ecosystem, challenges, and benefits

At the beginning of the online interview, respondents were asked to reveal the essence of the digital leadership ecosystem in their organisation. The results are shown in Table 11.

Table 11. Survey results on the essence of the ecosystem of digital leadership in the respondent's companies.

Respondent	The essence of the ecosystem of digital leadership in the company
Respondent #1	it is primarily a system that provides interaction between three components: people, technology, and data. The purpose of her work is to improve productivity and quality in construction primarily thanks to digital tools, for example, the BIM program (Building Information Modeling, which allows you to create virtual 3D models of buildings)
Respondent #2	it is about motivating staff to develop their abilities and skills, in particular digital, but still, the definition of this concept can vary significantly according to the unit, as well as the requirements, knowledge, and skills that are stimulated to improve in employees
Respondent #3	it is about using advanced technologies to build a powerful communication channel with our international partners that will enable our students and teachers to access international programs for learning, sharing experiences, and cooperation
Respondent #4	this is the use of programs for forecasting demand, online marketing, optimization of logistics processes, and supply management – we use automated warehouse and transport management systems to reduce delivery times and optimize costs

Table 11 (continue)

Respondent	The essence of the ecosystem of digital leadership in the company
Respondent #5	it is training employees in digital skills and developing their leadership qualities. Among the digital tools we use in our company are e-commerce platforms, advertising campaigns on social networks, and the active development of online marketing.
Respondent #6 and #14	it's about online learning and increasing the number of distance courses that both students and employees can take. A lot of attention is paid to non-formal education
Respondent #7	is the use of digital tools and strategies to effectively guide and optimize trading activities. We also use digital platforms for marketing and advertising
Respondent #8	these are educational programs and training for the development of digital skills of employees, the implementation of digital initiatives, their monitoring and evaluation of their effectiveness, in particular, the measurement performed of their impact on productivity, employee satisfaction
Respondent #9 and #10	it is the use of digital technologies to optimize production processes/the integration of digital technologies into production processes. First of all, it is the automation of production lines, improvement of monitoring and control systems
Respondent #11	it is the use of advanced technologies to improve the quality of our services and meet the needs of customers. We are focused on implementing digital tools such as online booking and electronic payment systems to make the process of receiving services more convenient and accessible for our customers.
Respondent #12 and #17	this is the use of software to automate routine tasks - compiling reports or distributing work tasks between employees, forming work schedules; as well as programs for training or familiarizing personnel with new robot technologies or methods
Respondent #13	it is encouraging our employees to create innovative products that meet the needs of the modern education market and ensure high quality of education, and we also analyze their effectiveness to make improvements.
Respondent #15	this is the implementation of a sales strategy that takes into account modern trends and digital marketing tools, investment in training and development of our staff, maintaining friendly relations with stakeholders
Respondent #16	it is the training of our employees to provide them with the necessary knowledge and skills to provide high-quality customer service. We have several digital communication channels for the customer, including web chat, social media, messengers, online feedback forms and contact forms.
Respondent #18	this is the internal innovative development of the company. To do this, we use creative digital approaches to meet customer needs, employee training and digital tools for feedback
Respondent #19 and #20	it is the creation of an innovative environment that promotes the development of students and teachers. We are committed to combining cutting-edge teaching methods with digital technology, providing deep understanding and hands-on experience

In conclusion, it is worth noting that the essence of the ecosystem of digital leadership varies depending on the sector of the company's activity and its internal characteristics. However, respondents noted that the ecosystem of digital leadership is about training employees, using digital technologies and tools to optimize the company's work, and improving efficiency, and the quality of goods/services. A company's digital leadership ecosystem can include the following components: strategic leadership, digital initiatives, innovative culture, digital talent development, as well as internal and external communication and collaboration systems.

The respondents noted that the team advantages of adapting to the digital leadership ecosystem are optimization of working time and productivity improvement, improvement of the level of organisation and coordination in the team, the quality of performance of work tasks, and convenient and fast interaction

between team members. Respondent #17 noted (type of economic activity – medicine): 'Adapting to the ecosystem of digital leadership allowed us to simplify routine processes, and provide access to accurate and timely information, which allowed staff to make informed, comprehensive decisions'. Respondents #5, #4, and #7 (type of economic activity – trade) pointed to the speed and ease of use of digital tools. Respondents from the field of industry pointed to the possibility of constant monitoring of the current state of affairs, analysis of efficiency, and the ability to make rapid improvements. Respondent #8 (Head of HR) said: 'Among the advantages of adapting to the ecosystem of digital leadership, it's a partial change of corporate culture, internal environment from conservative to more innovative, coherent, open to cooperation and change.' Respondent #6 indicated that it is 'having flexibility and some freedom' compared to the traditional approach to leadership. Respondent #20 noted that the digital leadership ecosystem increased the level of digital literacy of employees and improved their leadership qualities, and Respondent #15 – improved the level of staff motivation and job satisfaction. 'We had a sense of stability and efficiency in the way things were, so we created a change strategy that included aspects that needed to be improved, such as the assessment system, which included digital tools to automate the assessment process and provide reports for students on their progress. The use of digital technologies and tools allowed us to improve the efficiency of service delivery and the use of working time' (Respondent #14, education and training).

The interviewed managers noted that the personal benefits of adapting to the ecosystem of digital leadership are increasing the productivity of their work, increasing the efficiency of management, and convenient access to data and analytics, which contributes to better decision-making. 'Among the personal advantages, I would single out rational management of one's own time, priorities, and workload. Digital tools have made it possible to collect, store, and process large amounts of data, which allowed it possible to effectively monitor various aspects of the company's activities (Respondent #2, industry). Respondent #12 noted: 'Among the advantages, once implemented, digital tools free up personal time that can be used for the solution of other tasks.' Adaptation to the ecosystem of digital leadership increased flexibility and speed of response to changes in market conditions (Respondent #16) and increased personal productivity due to increased motivation and coherence in teamwork (Respondent #4).

Ukrainian companies found themselves in an environment of constant changes and complex challenges, which require managers not only to think strategically but also to be extremely flexible and able to effectively respond to unforeseen circumstances. Among the key aspects that constituted team challenges for the respondents during adaptation to the digital leadership ecosystem were the rational management of time, priorities, and workload of employees, and feeling afraid of the uncertainty of the future. 'We have developed evacuation and response plans in case of emergencies, equipped a shelter that will allow protecting all our employees' (Respondent #6). 'Feeling overloaded at work, loss of attention and concentration on main goals. The fact is that at the beginning we wanted to organise a lot of digital projects, which were not successful but only led to emotional burnout of the team. Of course,

this was an important experience, but we resumed work on the implementation of digital tools only recently' (Respondent #7). Among the challenges, interviewed managers also noted the need for continuous training (Respondent #1, #3, #10, #13, #19), change in work habits and techniques (Respondent #11), reorganisation of work processes (Respondent #9), improvement of skills in using digital tools, adaptation to the use of new digital technologies (Respondent #10, #12). 'The challenge was the implementation of digital processes in the work because usually, the processes that need to be implemented require adaptation to already existing processes. This was a significant complication because this issue was investigated already during implementation and the responsibility was placed on direct workers, which provoked their overload and reluctance to implement changes' (Respondent #12). Respondent #19 highlighted the need to coordinate team efforts and create a favorable environment for innovation and collaboration. 'Among the team challenges is the need to organise the work process, because it is quite difficult to effectively measure the work of each employee at the stage of implementing digital initiatives since we are constantly testing new ideas, which requires a significant amount of time to search information, conduct the testing itself, and identify shortcomings. That is why we organised clearly the work process, identified areas of responsibility, and automated the process of 'transfer of ideas' from one stage to another ' (Respondent #18).

The role of the team in managing challenges is extremely important. The collective effectiveness of a team can quickly solve problems and adapt to change, which is often difficult or even impossible for a single employee or manager to do. However, at the same time, the team can inhibit the implementation of digital initiatives. 'Among the team challenges – was resistance from senior employees, which occurred due to increased workload in the work schedule and, to some extent, lack of confidence in their abilities. We simply solved this issue – we implemented changes in one work process and demonstrated them to employees in comparison with the current one, and also allocated a period in the working time of employees for familiarization and training in the use of digital tools' (Respondent #13). 'Misunderstandings and conflicts arose due to instability and the rapid pace of change, in particular, conflicts occurred among different age categories of employees, but thanks to the implementation of additional training, slowing down the pace of digitalization, defining common goals and increasing cooperation, joint responsibility in the team - we managed to overcome it' (Respondent #20). 'I can't say that we faced certain challenges, of course, at the beginning, there were difficulties in getting used to new methods, but each employee understood the purpose and the reason for doing it' (Respondent #17). The structure and format of collaboration in a team can create new or additional challenges for the team. 'Since we cooperate with the team remotely, there was a feeling of limitation in identifying and developing the talents and skills of employees due to remoteness. However, thanks to systematic online discussions of employee expectations, their progress in their skills and abilities, and assessment of individual needs, we managed to improve the situation' (Respondent #15).

No less important next to the team challenges are the personal challenges faced by the leaders. After all, these factors can significantly affect the psychological state of the manager, and his ability to make

decisions and manage the team. Interviewed executives shared the personal challenges they faced while adapting to the digital leadership ecosystem. The feeling of lack of own skills and abilities, which provoked a significant load on the work schedule at the beginning of the implementation of the ecosystem of digital leadership (Respondent #1, #4, #10). A sense of own limitations and the use of outdated methods in management (Respondents #8 and #9), a decrease in personal motivation (Respondents #4 and #9), the need to develop new methods of communication with the team (Respondent #9), overload due to constant access to work (Respondent #18). 'The need for constant improvement and training has caused a constant need to find new ways of motivation both for me and for the team. That is why various events are commonplace in our company' (Respondent #4). 'Among the personal challenges, I would highlight the need for constant learning and testing of new ideas' (Respondent #13). The need to master and use new digital tools (Respondent #10, #11, #16). 'The need to quickly adapt to new technologies and tools, while a certain resilience and stability was felt when using old approaches' (Respondent #16). 'I often had a sense of instability due to the rapid pace of change and the saturation of initiatives being implemented. A visual representation of the goal we are striving for and the steps that still need to be taken and that have already been taken, the dynamics of increasing the number of regular customers and financial resources from the company helped. This made it possible to see the 'foundation' which was made and to feel a certain level of security' (Respondent #5).

3.3.2. The influence of the digital leadership ecosystem on the personal qualities of managers, management practices, and interaction in the company

Changes in the modern environment require managers not only to have strategic thinking and effective management but also to be able to adapt to the rapid development of digital technologies. Digital technologies change or transform the way we live, communicate, work, and produce goods and services. However, along with the changes come the need for new personal qualities, managing skills, and management practices. The respondents shared their own experiences of changing personal qualities under the influence of the digital leadership ecosystem.

Among the impact of the digital leadership ecosystem on personal qualities and skills, a significant part of managers highlighted the improvement of adaptability, digital literacy, flexibility, time management, and stress resistance. 'The experience of interacting with employees in a digital environment developed my ability to adapt to different work styles, and communication, allowed me to better understand others and their position even in the absence of 'live contact'' (Respondent #15). 'The level of efficiency, self-development, and creative thinking has improved. After all, if something didn't work out or didn't succeed, we had to look for new ways and come up with different ideas' (Respondent #4). The interviewed managers also pointed to an improvement in the level of self-organisation, planning, responsibility, systemic thinking, and the ability to critically analyze and evaluate information. 'The ecosystem of digital leadership allowed me to develop my own strategic skills, skills of critical analysis, and evaluation of

information, added the ability to effectively resolve conflicts and reach a consensus in any situations' (Respondent #13). The ecosystem of digital leadership contributed to the development of the ability to work in multitasking mode (Respondent #12), to simpler and easier perception of risk, better formation of strategic vision and thinking about the future of the company, and digital platforms helped to develop skills in more effective promotion of ideas and services (Respondent #6).

Respondents indicated not only the impact of the digital leadership ecosystem on personal qualities and skills but also on rethinking their work, the organisation of work in the company, and the possibility of improving both. 'Using digital tools has encouraged me to collect and analyse feedback on the work I do to continuously improve the skills and services I provide' (Respondent #14).

The next stage of the survey was questions related to the change of management practices under the influence of the ecosystem of digital leadership. Management practices mean strategies, methods, and actions that the manager used/uses to effectively manage and organise the work of the team, and the organisation in general. This change reflects the transition from traditional management methods to more flexible and innovative approaches that can increase competitiveness and create an advantage for the company in the market. At the same time, the change in management practices emphasizes the readiness for innovation, which is one of the key components of successful leadership in the digital age. The responses of the respondents received during the online interview are shown in Table 12 in abbreviated form with the main content displayed.

Table 12. The impact of the digital leadership ecosystem on management practices

Respondent	The impact of the digital leadership ecosystem on management practices
Respondent #1	More active use of cloud services and tools for collaborative work. This allows each team member to have the level of access to the project that they need and enables remote work.
Respondent #2	I can't say that there has been a significant impact or a definite change.
Respondent #3	Active use of video conferences for communication with the team and other organisations. Using digital programs to plan own and team working hours. This made it possible to effectively distribute work tasks among team members and monitor work processes.
Respondent #4	Use of digital tools for internal audit. This made it possible to check internal processes and procedures more effectively for compliance with requirements and standards.
Respondent #5	Using digital tools for employee studying.
Respondent #6	Use of online learning and digital platforms to develop personal, team knowledge and skills, which provided an opportunity for continuous self-development of staff.
Respondent #7	Using digital tools to motivate employees. The motivation system is built in such a way that each employee can set, and track their personal goals and objectives, and compare them with the company's overall goals. For achieving their own goals, employees receive internal points, which are later converted into a reward in the form of cash, an additional day off, or a ticket for a short trip.
Respondent #8	We paid attention specifically to the development of communication culture in the organisation, which allowed us to achieve mutual understanding in the team and create a strong team. We have created our chat, where employees can communicate and share ideas not only on work topics. For example, recently we shared recipes for preparing signature dishes.

Table 12 (continue)

Respondent	The impact of the digital leadership ecosystem on management practices
Respondent #9	The use of digital tools for planning the work process and time, the use of shared cloud services, software for monitoring the quality of manufactured products.
Respondent #10	Using digital analytical tools to optimize inventory management processes.
Respondent #11	The use of digital platforms for collaboration it allowed the entire team to work effectively, regardless of location.
Respondent #12	Using data analytics. For example, we use analytical tools to monitor and analyze equipment operation data to identify potential problems, possible failures in operation.
Respondent #13	Using more flexible and innovative management practices. For example, instead of the traditional method of development, which involves the end of each project stage before the start of the next one, we switched to an agile approach. The essence of this consists of short iterations (short repetitions of certain actions or operations to achieve the desired result, sprints). Each sprint can include the development, testing, and implementation of new features. This allowed us to introduce ideas and improvements to our product more quickly.
Respondent #14	Using digital tools to manage knowledge and experience within the team. For example, we use Notion to store data and ideas for a specific project or task. If a team member is not involved in a given project but has relevant experience or knowledge, we give him the appropriate level of access to be able to offer ideas, suggestions for improvement.
Respondent #15	The use of digital technologies made it possible to create effective conditions for cooperation with a remote team, providing access to the necessary resources and common tools, and the ability to maintain 'close relations' with employees.
Respondent #16	The use of a digital staff development plan, which allows each employee to see the necessary areas for personal and professional growth.
Respondent #17	Using digital tools to work together, allowed us to feel more confident in the decision-making process. Collecting and analyzing feedback from employees and customers, allowed continuous improvement of work processes.
Respondent #18	Using innovative digital tools to stimulate creativity and innovative thinking in a team. Also, digital tools made it easier to perform work in multitasking mode.
Respondent #19	Digital tools allowed me as a leader to respond quickly to changes, quickly review and evaluate the state of workflows, and provide a more flexible allocation of resources and tasks.
Respondent #20	The ecosystem of digital leadership has expanded the possibilities of organising the work of the team and increased the efficiency of the staff, in particular by using online tools for collaborative work.

Respondents under the influence of the ecosystem of digital leadership on management practices noted the use of digital tools and technologies for various purposes: optimization of inventory management processes, training, and development of personnel, conducting internal audits or improving efficiency. However, digital tools also affect the interaction between the manager and subordinates, because previously it was limited to a physical workspace and defined hours. With the advent of digital tools such as online collaboration platforms, virtual meetings, and instant messaging, communication has become more flexible and efficient. With digital technology, managers can easily share information, plans, and achievements, which helps to reduce uncertainty and increase employee engagement. Respondents shared their own experiences on this issue, the results of which are shown in Table 13.

Table 13. Impact of the digital leadership ecosystem on the interaction between employees and managers

Respon-dent (R)	The positive impact of the digital leadership ecosystem
R #1	It allowed me as a manager and the team to interact at any time and from any location.
R #3	Fast interaction has ensured a certain 'transparency' in our work, as it is possible to track who is working on what task at any time, what their progress is, and deadlines.
R #4	It provides employees with up-to-date and reliable information, as the dissemination of necessary data happens quickly and efficiently.
R #5	The level of employee engagement in discussing decisions and initiatives has increased. They have become freer to express their ideas and thoughts.
R #6	The level of communication between staff and management has improved, as each employee has equal access to information and opportunities, regardless of location or work schedule.
R #7	In my opinion, it has allowed us to create an environment that stimulates innovation and ideas from the staff, fostering 'open dialogue' communication. Employees have become freer to share their thoughts and express their views on various matters
R #8	The level of employee engagement and interaction has improved.
R #9	Coordination and cooperation within the team have improved thanks to quality communication.
R #11	The digital leadership ecosystem has increased the speed and level of interaction with employees.
R #13	Employees have become more initiative-taking, independently proposing ideas to improve work processes, or pointing out shortcomings in them.
R #14	As a manager, I have become more effective in understanding the needs and capabilities of the team, while employees feel more confident in their abilities, as their ideas and experience are valued and considered in decision-making. This has increased our efficiency in cooperation and team cohesion.
R #15	Digital tools have allowed me to better understand the needs, skills, and abilities of employees, to coordinate efforts more effectively to achieve common goals.
R #16	The efficiency of cooperation and teamwork has improved.
R #17	Digital tools have allowed us to share information effectively and quickly between management and the team, as well as among team members, ensuring constant access to up-to-date information.
R #18	There has been active employee involvement in discussions and decision-making
R #19	The digital leadership ecosystem has created more opportunities for open communication and cooperation.
R #20	The digital leadership ecosystem has provided staff with more opportunities for self-expression and development, as they can use various resources and tools for joint learning with colleagues and self-study, which increases their motivation and engagement in the work process. This has positively impacted the interaction between employees, between employees, and me.
Respon-dent (R)	**The negative impact of the digital leadership ecosystem**
R #7	However, digital tools in some way 'blur the lines' between work and personal time, leading to burnout for both me and my subordinates.
R #10	The constant flow of messages and tasks in different interaction channels creates information chaos and overloads the staff.
R #12	My interaction as a manager with higher management has worsened, as they do not understand the real need for implementing digital technologies and do not explore the feasibility of their implementation. With my subordinates, we have become more efficient, but it is hard to say whether this was due to the influence of the digital leadership ecosystem.

Table 13 (continue)

Respon-dent (R)	The negative impact of the digital leadership ecosystem
R #15	However, it is harder to motivate staff and maintain their engagement when we work remotely.
R #18	However, constant availability for work creates pressure on both me and the team, as you are online 24/7. This negatively impacts our relationships and interactions.
R #20	However, not all employees have the same level of digital skills, complicating joint interaction and relationships within the team.
Respon-dent (R)	**The neutral impact of the digital leadership ecosystem**
R #2	I can't say that there has been any impact or change.

The digital leadership ecosystem can have both positive and negative effects on leader-team interactions. On the one hand, digital tools provide transparency and availability of information, which increases the involvement of employees in the discussion of decisions and initiatives. This creates an environment of open dialogue where every employee can express their ideas and opinions freely. 'The digital leadership ecosystem has created more opportunities for open communication and collaboration. For example, the use of specialized platforms for project management allows me as a manager to easily set tasks, track progress, and provide the necessary support to the team, which increases the efficiency of our work' (Respondent #19). On the other hand, constant access to digital means of communication can lead to burnout, because the boundaries between work and personal time are blurred. This creates additional pressure on both the manager and the employees. In addition, not all employees have the same digital skills, which can lead to an imbalance in the team and make it difficult to interact. Effective use of the digital leadership ecosystem requires a careful balance between its benefits and potential challenges.

One of the key elements of the digital leadership ecosystem is the development of employees' digital skills. Digital leadership involves not only the use of digital technologies but also the formation of a culture where every employee has the necessary digital skills to work effectively. This allows the company to remain competitive, adaptive, and to some extent innovative. Respondents shared specific steps their companies are using to develop digital skills in staff and management. The results of the survey are shown in the Figure 13.

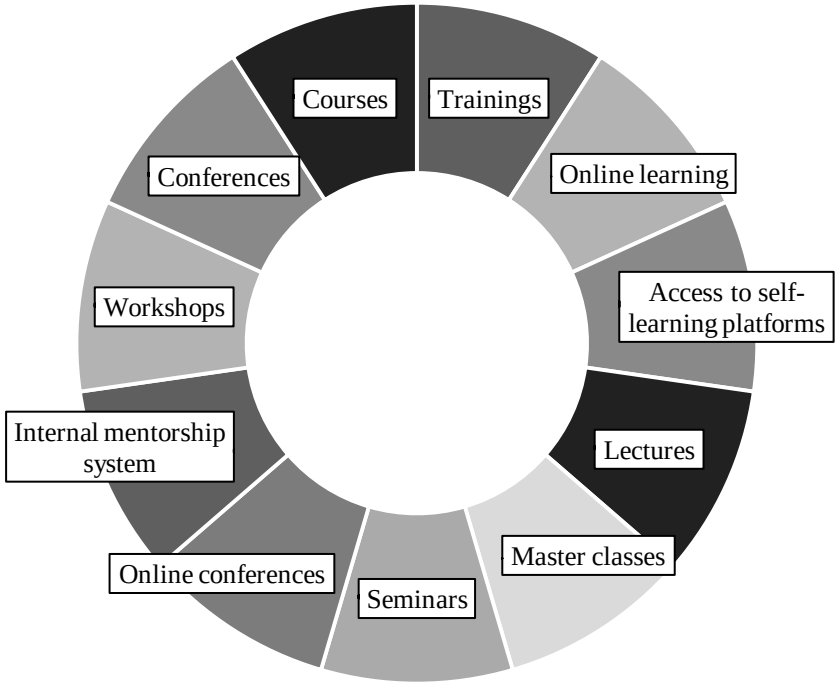

Figure 13. Steps taken by the respondents' companies to develop digital skills among staff and managers.

Most respondents shared the training formats they use to develop staff digital skills. ‘Access to online training, distance courses, thematic lectures, seminars, workshops, continuous assessment and analysis of the level of digital skills of staff to identify needs for additional training and development' (Respondent #19). However, this does not have a significant impact on employee motivation, and therefore, under such conditions, it is difficult to form and develop a digital leadership ecosystem culture. ‘A motivation system that is built on internal scores and goals that, in the employee's opinion, should be achieved, but they undergo certain moderation’ (Respondent #7). It is also a problem that companies conducted training only at the initial stages of implementing digital initiatives and tools, which subsequently slows down the digital development of employees. ‘At the beginning of the implementation of digital initiatives, we had an internal mentoring system, thanks to which every employee could understand the details of the new tools to use the benefits of their implementation as effectively as possible’ (Respondent 17).

Digital technologies are significantly transforming management practices, which require new approaches and skills from managers to effectively manage a team in a modern digital environment. However, the introduction of these technologies can both facilitate and hinder the formation and development of leadership qualities. To understand whether and how digital technologies affect leadership qualities, this question was asked of managers during the survey. The results of the survey are shown in Figure 14.

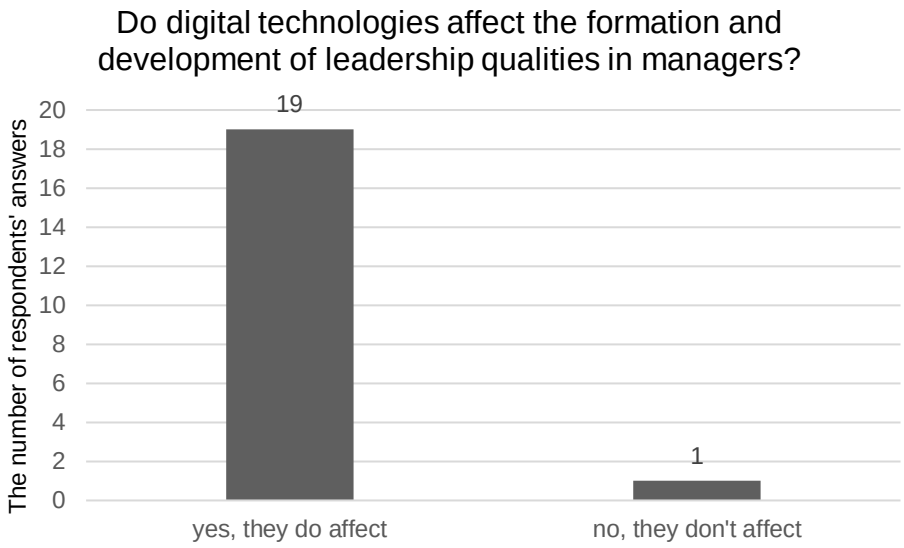

Figure 14. The survey results on the presence or absence of the influence of digital technologies on the formation and development of leadership qualities in managers

Interviewed leaders shared their own experiences of how digital technologies influence the formation and development of leadership qualities. Among the ways respondents felt that digital tools have made it easier to communicate and interact with subordinates (Respondent #1, #6, #7, #11, #15, #17, #20), provided access to information that is valuable to me as a manager (Respondent #1, #2, #6, #7, #14). ‘They provide an opportunity for the leader to improve communication with subordinates and access to information that is valuable, especially in the decision-making process’ (Respondent #1). Implementing your own ideas with high quality has become easier (Respondent #5, #18), solve problems and challenges more effectively (Respondent #5, #17), expanded the possibilities of the leader's influence on the team (Respondent #11). ‘Digital technologies have given leaders access to a wide range of tools for personal development, communication, and effective analysis of large amounts of data and informed decision-making, enabling them to improve their analytical and strategic competence.’ (Respondent #20). Digital tools have enabled leaders to be more adaptive, and flexible and provide significant opportunities for self-development and learning. Table 14 shows some of the respondents' opinions about the impact of digital tools on leadership qualities.

Table 14. Some respondents' views on the impact of digital technologies on the formation and development of leadership qualities

Respon-dent (R)	The impact of digital technologies on the formation and development of leadership qualities
R #9	‘‘They provided the opportunity to have quick access to data and information and also contributed to innovation in solving business challenges. Thus, leaders who skillfully use digital tools can be more adaptive, transparent, and innovative in their management and leadership.'
R #10	‘Digital technologies have allowed leaders to be more flexible in their actions, knowledge, and skills, to respond more quickly to market changes. They provided opportunities for self-education and self-development, which contributed to my professional growth, particularly the development of leadership qualities.'
R #14	'In my case, digital technologies helped to develop my leadership responsibility - increasing access to resources and information, it led to an increased incentive to make important decisions independently and take responsibility for their results.'
R #16	‘Digital technologies stimulate self-development and the desire to learn something new. When you realize the benefits that this digital initiative can bring to your team and company, it automatically prompts you as a manager or leader to search for information, self-study, and test this digital tool or technology, to later personally and by your example demonstrate the benefits to employees.'
R #18	‘Digital development stimulates managers to innovate and find new ways for business development, which is an important leadership quality.'
R #19	‘The success of today's leaders in solving complex management tasks and leadership challenges depends to some extent on their ability to take advantage of the digital environment. Digital technologies contribute to the development of innovative thinking, the ability to effectively manage projects and teams in conditions of high uncertainty and complexity.'

19 out of 20 respondents indicated that digital technologies influence the formation and development of leadership qualities in managers, one of the respondents expressed the opposite opinion. ‘Digital technologies are making several aspects of management easier by providing quick access to data and a variety of decision-making tools.' (Respondent #13). In addition to the impact on his leadership qualities, one of the respondents noted that digital technologies allowed him to achieve new results from strategic cooperation. ‘In my opinion, digital technologies influence the formation and development of leadership qualities in managers. In my case, I was also able to significantly expand my own network of contacts and find new opportunities for partnership and cooperation. And it all started with the application for participation in the digital training program’ (Respondent #3).

One of the stages of the online interview was to ask the respondents about the competitive advantages that the company has gained in the market thanks to digital initiatives, and what digital opportunities executives are currently focused on. The results regarding the competitive advantages gained by the companies are presented in a condensed format in Table 15 and are grouped according to the economic activities of the companies.

Table 15. Competitive advantages gained by the companies of the respondents we surveyed in the market through digital initiatives.

Respondent number (R)	Competitive advantages gained by the companies in the market
Services Sector	
R #11	Digital initiatives have enabled us to use working time more efficiently, which has increased employee productivity and contributed to the expansion of our customer network.
R #16	The quality and speed of customer service has improved, the speed of response to changes and non-standard situations has increased.
Trade	
R #4	The process of resource management and data analysis has improved, which has led to a reduction in costs. Also, the company's marketing level improved.
R #5	The number of platforms to communicate with customers increased, which improved their level of engagement and increased sales.
R #7	The level of satisfaction of our customers, the effectiveness of promoting products in the market has increased, which has led to increased sales volumes and improved market positions for our products.
Industry	
R #2	The level of information and data security has increased.
R #9	Productivity increased, the number of defects in the production process decreased, which led to a decrease in costs. We have become more flexible in responding to changes, both internal and external.
R #10	Increased productivity throughout the company.
R #12	A part of routine tasks was automated, which made it possible to free up the working time of employees and direct it to solving other tasks.
Education and Training	
R #3	The number of partners has increased.
R #6	The level of student satisfaction has increased.
R #13	The quality of customer service has improved and the use of resources, including financial resources, has been optimized.
R #14	Work efficiency and quality of provided services have improved.
R #15	The number of clients increased this year, thanks in particular to online marketing and active management of social networks.
R #19	Thanks to digital initiatives, we have increased the accessibility of education, providing the opportunity for online learning and the use of distance learning resources, which is especially important now. This allowed us to keep students safe and provide them with quality education regardless of their location and of course, improved our market position.
R #20	The quality of education has improved thanks to the introduction of online tests, interactive educational materials, etc. The level of online marketing and its recognition among potential students has increased.
Types of economic activity that had one representative	
Medicine, R #17	The quality and speed of customer service has increased, and the level of difficulty in communicating with them has decreased.
Transportation and Communication, R #8	The level of interaction and digital literacy of employees has increased. This allowed us to use available resources more efficiently, respond to changes and innovations faster, and improve the quality of customer service.
Construction, R #1	It is actually difficult to say about competitive advantages in the market, but the implementation of digital initiatives has optimized some work processes and freed up the working hours of employees. This, in turn, enabled us to complete tasks and projects more quickly.
E-commerce, R #18	They allowed us to promote our brand more effectively in the digital space, which increased its recognition and authority.

Digital capabilities aren't only a wide range of tools and technologies that help maintain a competitive advantage, but they also enable the achievement of strategic goals faster and more efficiently. Some respondents and their companies are not focused on certain digital opportunities currently. However, some still actively use digital technologies and put them at the center of their strategy to achieve competitive advantages and strategic goals of the company. Now, we are focused on automating certain processes, which will allow us to reduce operational risks and errors in work' (Respondent #7). 'The next step according to the company's digital strategy is to improve the security of the work environment. That is why we are currently focused on digital capabilities that will help us achieve this' (Respondent #10). Respondent companies are also focused on digital initiatives that will improve employees' digital literacy, knowledge, skills, and abilities. (Respondent #2, #9, #14). 'We are currently actively implementing digital capabilities to improve data analysis to support management decision-making' (Respondent #19). Digital capabilities in the surveyed companies are aimed at increasing the network of partners (Respondent #3), and improving cyber security (Respondent #13). The focus of digital opportunities on which managers and their companies are oriented depends mostly on the economic type of the organisation and the market situation. 'At this stage, digital initiatives are aimed at improving the quality of education, interactive communication between teachers and students, increasing the reputation of the university' (Respondent #20).

3.3.3. Corporate culture and implementation of digital initiatives

Corporate culture is one of the factors that affects the success or failure of digital initiatives in the company because it determines how employees interact with each other, react to changes and innovations, as well as how decisions are made within the company. Corporate culture can both facilitate and hinder the implementation of digital initiatives. Respondents shared their own experiences regarding this issue.

'After all the changes that happened to all of us, there is probably a high level of openness to change in our corporate culture, so my colleagues were interested in the changes, and there was no resistance. Moreover, they offered their ideas on how to make the processes more user-friendly' (Respondent #3). The corporate culture contributed to the rapid acceptance by employees of new changes and adaptation to new technologies (Respondent #5, #6, #19, #20). 'The corporate culture has facilitated the implementation of digital initiatives because marketing is a field where every employee is creative and open to something new. Therefore, everything happened quite easily' (Respondent #5). 'Employees supported and helped each other, which made it possible for all team members to achieve approximately the same level of digital literacy. This brought the team even closer and provoked the absence of negative emotions in the staff in connection with the implementation of digital initiatives' (Respondent #6).

During the implementation of digital initiatives, some respondents encountered difficulties related to corporate culture. ‘At first, the employees were afraid and unwilling to change anything – this lasted for about a month. After analyzing the situation, we decided to form a system of additional payments based on the implementation and use of the necessary digital tools in the work. It paid off – after 3 months we achieved the desired results’ (Respondent #1). Corporate culture inhibited the process of implementing digital initiatives (Respondent #4, #8, #9, #10, #12, #13, #14). The reasons for the inhibition were: employee resistance, as they believed that it would only complicate their work and require additional training efforts; employees were distrustful and felt that their jobs were threatened; there was a lack of necessary experience and knowledge, which provoked fear and uncertainty; staff were focused on the status quo and did not want to change anything; and there was a lack of communication and understanding between senior management and employees.

Among the ways respondents overcome corporate culture obstacles, the following were mentioned: implementation of a gradual and easy training system, arguing the importance of changes and creating a culture of closeness and trust, implementation of a change strategy to combat stability. ‘As a manager, I faced a lack of understanding of the benefits of implementing digital tools and a lack of cooperation between departments. The technical department did not understand the real situation and the needs of the employees, and the employees, in turn, did not even consider the proposals that were put forward. We solved this problem in the following way: for a certain period, employees of the technical department worked together with the employees, which allowed us to improve their relations and change the proposals for improving the production process per the real needs. Once all the proposals were improved, the implementation plan and benefits were demonstrated to the employees, who quickly accepted them. Once a month, the technical department works together with the workers for 1-2 working days’ (Repondent #9). Some of the surveyed respondents who noted difficulties with the implementation of digital initiatives due to the corporate culture, are still looking for solutions to these problems.

Some of the surveyed managers noted that the corporate culture did not influence the implementation of digital initiatives (Respondent #11; #16; #17 #18). Respondents also found it difficult to assess the impact of corporate culture (Respondent #2; #7; #15), through the remote format of work (Respondent #15) and the introduction of digital initiatives with the start of the company's existence and work, when the digital culture had not yet been formed (Respondent #7). ‘In our case, digital culture didn’t particularly influence the implementation of digital initiatives, because there was no resistance or support from employees, they implemented digital tools out of necessity. Therefore, there was no resistance or enthusiasm from the workers’ (Respondent #17).

3.3.4. Digital strategy

Digital strategy is extremely important in the digital leadership ecosystem because it provides a systemic approach to change management and can help create competitive advantages. Among these may be: increasing the flexibility and adaptability of the company, development and innovation, efficiency, and increasing the level of customer satisfaction and loyalty, in particular due to the rapid satisfaction of customer needs and prompt response to changes in the digital environment.

The results of a survey of respondents regarding the presence or absence of a digital strategy in their company are shown in Figure 15.

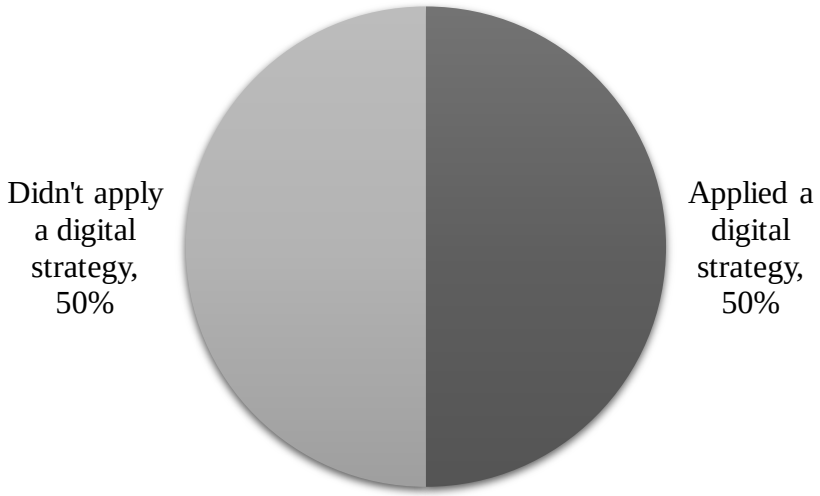

Figure 15. Availability of digital strategies in the companies of the surveyed managers

The type of digital strategy largely depends on the digital literacy of the employees and the manager, because in different cases it involves using different digital tools and focusing on different aspects of the company's development. Thus, based on the answers of the respondents, a matrix was created to determine the type of digital strategy most suitable for the organisation according to the level of digital readiness of the staff and the manager. The result is shown in Figure 16.

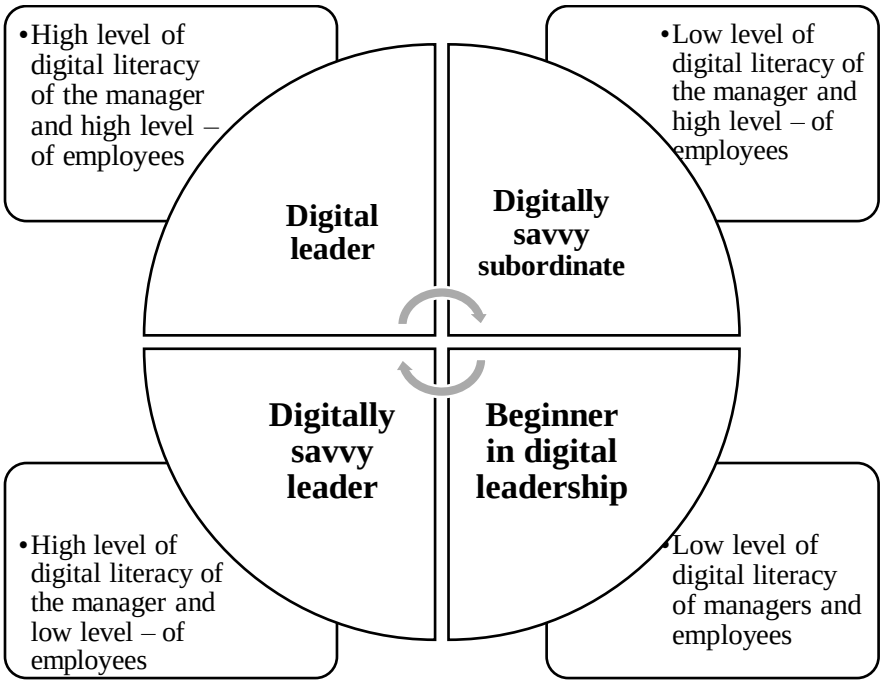

Figure 16. The company's digital strategy according to the digital competence of the manager and staff

This figure was created based on an example from the work of Vavdiiuk and Pivnytska (2022)

Digital strategy provides organisations with the necessary approaches and tools to effectively implement digital technologies and achieve strategic goals. The respondents talked about the existence of long-term strategies (Respondent #4, #5, #9, #10, #15, #19, #20), which could include the presence of the necessary number of short-term strategies. 'Our company has a long-term digital strategy. The first stage of which – optimization of production processes – was successfully implemented. The second stage is the creation of an innovative environment where each employee would be able to freely express their ideas and improve and improve their knowledge and skills. We are currently working on this' (Respondent #9). However, the managers interviewed pointed to the presence of only a short-term strategy (Respondent #1; #7; #14), which mainly involved improving a certain process or stage in the company's work. 'Yes, our company has a digital strategy, but they are rather short-term. Digital strategies are based on the implementation of digital initiatives when the company has a need. For example, our company is currently focused on implementing several digital cybersecurity initiatives' (Respondent #2).

The last –fifth hypothesis of this study aimed to investigate the relationship between the gender of respondents and the use of digital strategy. For this purpose, the contingent coefficient was used - Eq. 15, and the following hypotheses were formed:

Null hypothesis (H_0): The relationship between the gender of the respondents and the use of a digital strategy is statistically significant.

Alternative hypothesis (H_1): The relationship between the gender of the respondents and the use of a digital strategy isn't statistically significant.

The contingent coefficient was equal to the correlation coefficient between two variables and was used to measure the strength of the relationship between indicators measured on a nominal scale. The contingency coefficient was calculated based on Eq. 15.

$$V = \frac{n_{11} \times n_{22} - n_{12} \times n_{21}}{\sqrt{n_1 \times n_2 \times n_{1*} \times n_{2*}}} \quad [15]$$

A selective distribution of attribute 'A' (gender) was carried out depending on feature 'B' (application of digital strategy). The results of the sampling distribution are shown in Table 16.

Table 16. Selective distribution of attribute 'A' (gender) depending on attribute 'B' (use of digital strategy).

	A_1 (male)	**A_2 (female)**	**n_i**
B_1 (Applied a digital strategy)	2	8	10
B_2 (Didn't apply a digital strategy)	6	4	10
n_j	8	12	20

The next stage was the calculation of theoretical frequencies based on Eq. 16.

$$n_{ij} = \frac{n_i \times n_j}{n} \quad [16]$$

Calculations of theoretical frequencies for all cells of the table are given in Eq. 17-20.

$$n_{11} = \frac{n_{i1} \times n_{j1}}{n} = \frac{10 \times 8}{20} = 4 \quad [17]$$

$$n_{12} = \frac{n_{i1} \times n_{j2}}{n} = \frac{10 \times 12}{20} = 6 \quad [18]$$

$$n_{21} = \frac{n_{i2} \times n_{j1}}{n} = \frac{10 \times 8}{20} = 4 \quad [19]$$

$$n_{22} = \frac{n_{i2} \times n_{j2}}{n} = \frac{10 \times 12}{20} = 6 \quad [20]$$

The coupling of theoretical frequencies is shown below in Table 17.

Table 17. Connectivity of theoretical distribution frequencies

	A_1	A_2	n_i^*
B_1	4	6	10
B_2	4	6	10
n_j^*	8	12	20

To test the independence of attributes 'A' and 'B', we checked H_0: $p_{ij} = p_i \times p_j$ for all i and j. The x^2 statistic was calculated based on Eq.21.

$$x^2 = \frac{(n_{ij} - n_{ij}^*)^2}{n_{ij}^*} \quad [21]$$

Where p – the probability of a random event, the probability of the appearance of any specific combination of values of these attributes, n_{ij} – observed frequencies.

If the value of x^2_{obs} fell into the critical region: $x^2 > x^2_{obs}$ (α; v=1), then the null hypothesis was rejected with a probability of error α, and the attributes are considered dependent. The calculation of the x^2 statistic is shown in Eq. 22.

$$x^2 = \sum\sum \frac{(n_{ij} - n_{ij}^*)^2}{n_{ij}^*} = \frac{(2-4)^2}{4} + \frac{(8-6)^2}{6} + \frac{(6-4)^2}{4} + \frac{(4-6)^2}{6} = 1 + 0.67 + 1 + 0.67 = 3.34 \quad [22]$$

The relationship between gender and the use of digital strategy was measured using the coefficients of association (connectivity). The calculation of the contingent coefficient is shown in Eq. 23.

$$V = \frac{n_{11} \times n_{22} - n_{21} \times n_{12}}{\sqrt{n_1 \times n_2 \times n_{1*} \times n_{2*}}} = \frac{2 \times 4 - 6 \times 8}{\sqrt{10 \times 10 \times 8 \times 12}} = \frac{8 - 48}{\sqrt{9600}} = \frac{-40}{97.98} = -0.408 \quad [23]$$

Thus, the relationship between groups ‘A’ and ‘B’ is inverse. And since the modulo coefficient is greater than 0.3 (for empirical observations, this value is considered the minimum threshold for establishing a relationship between variables), this indicates that the relationship is confirmed, strong enough, and significant in the context of the study. The hypothesis is confirmed: There is a statistically significant relationship between the gender of respondents and the use of digital strategy.

3.4. The impact of COVID-19 and the full-scale russian invasion of Ukraine on the formation and implementation of the digital leadership ecosystem

All respondents acknowledged the impact of the COVID-19 pandemic as significant both for the formation and implementation of the digital leadership ecosystem and for the company's overall performance. It has shaken up their companies and posed new challenges, which, in particular, have prompted the development of the level of digitalization of organisations. Among the impacts of the pandemic on the formation and development of the digital leadership ecosystem, respondents highlighted the following: accelerated digitalization, changes in approaches to management, communication, and collaboration, including the increased use of remote collaboration with employees, companies began to invest more in training and development of digital skills of employees, as they became important for maintaining productivity and innovation in the conditions of that time. ‘During the COVID-19 pandemic, we started working remotely and actively using video conferencing to communicate with both our team and other organisations. Of course, the transition to the use of digital tools and the introduction of new digital technologies was quite fast, which was a significant challenge for employees. However, unfortunately, we needed this knowledge and skills once again when we faced another even bigger disaster - a full-scale russian invasion’ (Respondent #3).

During the COVID-19 pandemic, the risk was high, but there were still recommendations from doctors and rules of action to avoid or reduce the consequences of its impact. A full-scale russian invasion of Ukraine is a level of risk that is difficult to describe. Of course, there are rules of action for personnel and the company during air raids, etc., but sometimes the calculation can be a matter of seconds. The invasion presented the managers with a never-before-seen number of challenges and problems. And each of the leaders described it as the most difficult period of management and life.

Regarding the impact of the full-scale russian invasion on the formation and development of the digital leadership ecosystem, respondents noted the increased use of various digital tools to coordinate work and counter disinformation – this was also equally important in the work of companies because when employees were under constant stress, work was not productive and effective. Cybersecurity has become a significant part of the digital leadership ecosystem due to the threat of massive hacker attacks – it's the component that respondents didn't mention during the onset of COVID-19 influence, yet it became one of the foremost in this situation. Companies have started to introduce electronic services to provide services to customers, and the importance of innovation has increased. In the industrial sector, subsidies and business development opportunities have increased significantly, and in the healthcare sector, there are many opportunities for employee training.

Respondents noted that the Covid-19 pandemic and the full-scale russian invasion of Ukraine have significantly affected the formation and implementation of the digital leadership ecosystem, dramatically changed the market situation, and increased the flexibility and adaptability of companies to an unprecedented level. These events have accelerated digitalization, changed approaches to management and collaboration, stimulated innovation in various fields, and highlighted the importance of cybersecurity, but they have also caused many ruins and challenges for managers, employees, companies, and society.

Conclusions, Limitations, and Future Research Lines

The aim of this work was to determine the impact of the digital leadership ecosystem on the change in management profiles. To achieve this, managers of enterprises in the Volyn region of Ukraine were surveyed using a questionnaire consisting of two parts: a Google Forms survey and online interviews with open-ended questions. This questionnaire structure allowed for a thorough assessment of the influence of the digital leadership ecosystem on the transformation of personal qualities, knowledge, and skills of managers, as well as their interaction with subordinates and management practices. The questionnaire structure also facilitated the identification of challenges faced by managers during the adaptation to the digital leadership ecosystem. This work serves not only as a theoretical knowledge base but also as a practical tool that can be beneficial for managers in other enterprises. The obtained results can be used to develop strategies and measures that will contribute to the successful implementation of the digital leadership ecosystem and help overcome potential difficulties.

The sample size was calculated based on the formula for calculating the sample size for proportions with a confidence level of 85% and an error of 16%, as the online interview format required considerable time to conduct and analyse. The result was 20, so 20 managers of enterprises in the Volyn region were interviewed. Based on Pearson's statistics, the first hypothesis was confirmed that the results of the research can be trusted, and the sample comes from a normally distributed population. This gave confidence in the results and the opportunity to continue further research and analysis.

The surveyed managers work in the following economic sectors: transport and communication, trade, services sector, medicine, industry, education and training, e-commerce, and construction. Based on the respondents' answers, the overall level of digitalisation in companies was determined to be 3.7 points on a 5-point scale, falling between medium/neutral (3 points) and high (4 points).

The second, third, and fourth hypotheses of the research were accepted with a 95% probability based on the Mann-Whitney criterion – the difference in the sample sizes of these hypotheses can be considered insignificant:

Hypothesis #2: As the digital competence of executives grows, so will their digital leadership and vice versa.

Hypothesis #3: The digital strategy considers the digital risks of the organization's ecosystem and vice versa.

Hypothesis #4: Increasing the level of adaptability and flexibility of a manager leads to an increase in his/her self-awareness, gender equality, cultural and religious awareness, and vice versa.

Confirmation of all three hypotheses indicates that in the digital leadership ecosystem, the development of one type of digital skill among leaders contributes to the growth and improvement of other types of digital skills, i.e. they are interconnected.

Hypothesis #5: There is a statistically significant relationship between the gender of the respondents and the use of digital strategy, was confirmed based on the contingency coefficient. Half of the companies where the surveyed heads work didn't use a digital strategy, which is an important component of the digital leadership ecosystem. After all, it determines the direction and focus of the organisation, ensures the gradual and harmonious implementation of digital initiatives, contains stages for the development of digital literacy of employees and raising their professional level, allows monitoring and evaluating efficiency, making adjustments to the ecosystem of digital leadership. This indicates a gap in the scientific sector, because as of today there is no single approach to defining the essence of the ecosystem of digital leadership and its constituent elements.

Future research on this topic should be based on a more detailed exploration of the concept of a digital leadership ecosystem, the elements that make up the ecosystem, and the digital strategies that organisations and managers can use to build or improve a digital leadership ecosystem. The respondents confirmed that the values embedded in the corporate culture of an organisation can accelerate or slow down the implementation of digital initiatives and changes. This aspect requires further research to identify the specific factors that influence which values support or hinder digital initiatives. It is also important to investigate how the process of implementing digital change in an organisation can affect its corporate culture and whether changes in values can arise as a result of this process. Understanding these aspects will allow developing strategies aimed at maintaining the positive aspects of corporate culture and overcoming possible obstacles to the successful implementation of digital initiatives.

A limitation of this research was that it assessed the impact of the digital leadership ecosystem on managers' profiles only from the perspective of managers. In future research, it is important to make a comprehensive assessment of the impact, by interviewing employees at different levels of the organisation, experts, and other stakeholders. For example, if the type of digital leadership ecosystem is external or mixed, representatives of related companies could be interviewed. Further research could also assess the impact of the digital leadership ecosystem on employees, their level of digital literacy, interaction, and relationships in the team.

This work has a practical contribution to the research of the digital leadership ecosystem and its impact on management practices based on the responses of heads in the Volyn region of Ukraine. However, its limitations call for further research to gain a deeper understanding of this topic.

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Appendix

Appendix A

Survey questionnaire

A1. A survey in Google form:

Good afternoon!

My name is Karyna Kravchuk. I am a student in the double degree program between the Polytechnic Institute of Bragança (IPB, Portugal) and Lutsk National Technical University (LNTU). The topic of my master's thesis is: 'The impact of the digital leadership ecosystem on changing management profiles'.

Your answers will help to research this topic. This survey is confidential.

Thank you in advance for your time!

If you have any questions about the research or are interested in the results, you can contact me at karinakravchuk25@gmail.com.

Section 1. Personal data (please fill in)

1.1. Name

1.2. Position

1.3. Type of your company's economic activity

- Agriculture
- Industry
- Services
- Construction
- Financial activities
- Trade
- Transport and communication
- Innovation and research
- Tourism and recreation
- Education and training
- Other: ……..

1.4. How many employees are currently working in your company?

1.5. Your age (please select):

- up to 18 years
- 19-25
- 26-35

- 36-45
- 46-55
- over 56

Section 2: Impact of the digital leadership ecosystem (For each answer, please select a number from 1 to 5 - 1 (very low); 2 (low); 3 (neutral); 4 (high); 5 (very high);

2.1. Your assessment of the level of digitalization in your company today:

1-5

2.2 How would you rate your current level of digital skills?

a) Digital vision: having a personal and/or team digital strategy, ability to understand, analyze and implement digital technologies in the long-term and short-term work strategy

1-5

b) Digital competence: possession of the necessary personal, technical, creative, cognitive, social, including communication skills required to use digital technologies effectively

1-5

c) Digital leadership: the ability to manage and lead a team in a digital environment, motivate employees to achieve digital goals, and build a culture of openness, including openness to innovation

1-5

d) Adaptability and flexibility: the ability to adapt to 'digital challenges', to support innovative working practices and experimentation, while maintaining the 'strategic focus of the company'

1-5

e) Digital risks and cybersecurity: understanding one's digital responsibilities as an individual, employee, and leader, understanding potential digital threats and their consequences, and the importance of taking measures to protect data and infrastructure.

1-5

f) Self-awareness, gender equality, cultural and religious awareness: understanding one's impact on the digital environment in the team and building a corporate culture that provides equal digital opportunities regardless of gender, religion, or culture.

1-5

2.3. Your assessment of the level of compliance with these statements in your organisation:

a) From stability and conservatism to finding innovative solutions and adapting to change. The focus is on continuous innovation and flexible response to changes in the technological environment.

1-5

b) From internal control and competition to openness and cooperation. The company cooperates with various stakeholders: government agencies, universities, start-ups, and sometimes even competitors.

1-5

c) From authoritarian leadership and individual achievement to democratic leadership and collective achievement. The focus of your company's development is to stimulate the team to develop leadership

skills, generate new ideas, think innovatively, be open to new technologies and develop their own creative potential.

1-5

d) From ignoring new technologies to actively embracing them. The ecosystem in which the organisation is located facilitates comprehensive digital transformation by ensuring that digital strategies and advanced technologies are implemented across a variety of activities.

1-5

e) From maintaining a focus on the company's goals and plans to embracing all-round development and risk. Personal/collective learning and development is often focused on topics that are not related to the company's goals, and experimentation and risk-taking are a normal part of the job.

1-5

2.4. In this question, you can select multiple answers. What new skills and personal qualities did you need to build a digital leadership ecosystem in your organisation? (If a digital leadership ecosystem has already been established in your organisation go to 2.5)

- strategic thinking
- leadership qualities
- flexibility and adaptability
- creativity
- systemic thinking
- openness to risk
- empathy
- ethicality
- responsibility
- communication skills
- analytical skills
- knowledge and skills related to the use of digital tools
- ability to work in a team and cooperate with other organisations
- knowledge and skills in time management
- project management skills

Others:…….

2.5 If a digital leadership ecosystem has already been established in your organisation, what are the skills needed to effectively manage and improve it?

……

2.6 What type of digital leadership ecosystem does your organisation have? (Please select one)

- External – the company interacts with external stakeholders, and the ecosystem is focused on co-developing innovations, exchanging resources and data, as well as supporting digital advancement.

- Internal – grounded in internal processes, structures, and culture of the organisation itself, the ecosystem involves interactions between internal departments, teams, projects, and initiatives aimed at ensuring digital advantage and innovation within the organisation.
- Mixed (combines external and internal aspects) – integration of external and internal resources, processes, and strategies occurs, the ecosystem includes both external and internal components that interact not only separately but also collectively to achieve digital leadership goals. It may include joint projects, initiatives with external stakeholders, as well as internal processes aimed at supporting and utilizing digital opportunities and technologies within the organisation.

Thank you very much for your attention!
You can find a survey in Google Forms by following this link: https://forms.gle/SrsaN7BBK8irpYi66

A.2. Online interview in the format of open questions

1. What is the essence of the digital leadership ecosystem in your organisation?
2. What challenges have you faced in adapting to the digital leadership ecosystem: personal? Or team challenges? What were the benefits of adapting to the digital leadership ecosystem: personal? Team benefits?
3. How would you assess the impact of the digital leadership ecosystem on your personal qualities? Skills and abilities?
4. How has the digital leadership ecosystem influenced:
- management practices (strategies, methods, actions that you used/use to effectively manage and organise the work of teams and the organisation as a whole)?
- interaction between you (the head) and the team/subordinates? Employees?
5. How has your organisation's corporate culture facilitated or hindered the implementation of digital initiatives? (If it has, what were the obstacles, how did you overcome them, what does it look like now, and what changes do you want to make in the future?)
6. In your opinion, do digital technologies have an impact on the formation and development of leadership skills in managers? In what way?
7. What specific steps does your company take to develop digital skills among staff and management?
8. What competitive advantages has your company gained in the market through digital initiatives? What digital opportunities are you focusing on at this stage?
9. Does your company have a digital strategy, and if so, what does it consist of? Is it short-term or long-term?
10. How did COVID-19 and the full-scale invasion of the Russians affect the work of your company? Implementing or improving a digital leadership ecosystem?

Is there anything you'd like to add or highlight about the digital leadership ecosystem?

Appendix B

Table B1. Data for confirming hypotheses #2, #3, #4.

2.2 How would you rate your current level of digital skills?	Digital vision	Digital competence	Digital leadership	Adaptability and flexibility	Digital risks and cybersecurity	Self-awareness, gender equality, cultural and religious awareness
Respondent #1	2	4	3	3	3	3
Respondent #2	2	3	3	4	5	5
Respondent #3	4	3	3	4	4	5
Respondent #4	4	4	4	4	5	5
Respondent #5	4	4	4	4	5	5
Respondent #6	3	3	3	3	3	3
Respondent #7	4	4	5	5	5	5
Respondent #8	4	4	4	4	3	4
Respondent #9	4	5	3	4	4	5
Respondent #10	4	4	3	4	4	4
Respondent #11	4	5	5	4	4	5
Respondent #12	4	4	4	4	4	4
Respondent #13	3	3	3	4	2	4
Respondent #14	5	5	5	5	4	5
Respondent #15	4	3	4	5	4	5
Respondent #16	4	4	4	4	4	4
Respondent #17	4	4	4	4	4	3
Respondent #18	5	4	5	4	5	5
Respondent #19	5	5	5	5	4	5
Respondent #20	4	4	5	5	3	5

Appendix C

Confirmation of hypothesis #3

The third hypothesis of the research: 'The digital strategy considers the digital risks of the organisation's ecosystem and vice versa', was tested using the Mann-Whitney criterion – Eq. 12. For this purpose, null and alternative hypotheses were formulated:

Null hypothesis (H_0): The level of digital vision of managers wasn't lower than their level of signs in the group – digital risks and cybersecurity.

Alternative hypothesis (H_1): The level of digital vision of managers was lower than their level of signs in the group – digital risks and cybersecurity.

The comparison in Table C2 showed that the value of the choice X_{DRC} (digital risks and cybersecurity) was higher than that of the choice of Y_{DV} (digital vision), therefore, the choice of X_{DRC} was considered the first. The goal was to determine whether the difference between scores could be considered significant.

The first stage was ranking the table. When ranking, two samples were combined into one. Ranks were assigned in order of increasing value of the measured value, that is, the lowest rank corresponded to the lowest score. In the case of coincidence of rank for several respondents, the rank of such a score was considered the arithmetic mean of their positions occupied by these scores when they were arranged in ascending order.

Since there were related ranks (the same rank number) of the 1st row in the matrix, their reformation was done. Reshaping of ranks was carried out without changing the importance of the rank, i.e., the corresponding ratios – greater, less, or equal – had to be preserved between the rank numbers. The rank was not set above 1 and below a value equal to the number of parameters (40). The transformation of ranks is given in the Table C1.

Table C1. Rank transformation (digital risks and cybersecurity, digital vision)

Numbers of places in the ordered sequence	Position of factors in the respondent's (expert's) assessment	New ranks
1	2	2
2	2	2
3	2	2
4	3	6.5
5	3	6.5
6	3	6.5
7	3	6.5
8	3	6.5
9	3	6.5
10	4	21
11	4	21
12	4	21
13	4	21
14	4	21
15	4	21
16	4	21
17	4	21
18	4	21
19	4	21
20	4	21
21	4	21
22	4	21
23	4	21
24	4	21
25	4	21
26	4	21
27	4	21
28	4	21
29	4	21
30	4	21
31	4	21
32	4	21
33	5	36.5
34	5	36.5
35	5	36.5
36	5	36.5
37	5	36.5
38	5	36.5
39	5	36.5
40	5	36.5

The process of leveling the ranking results followed similarly to the process of leveling the ranking results that were applied to confirm the second hypothesis. The ranking results for the selection value of X_{DRC} (digital risks and cybersecurity) and Y_{DV} (digital vision) are shown in Table C2.

Table C2. Ranking results for the value of choice X_{DRC} (digital risks and cybersecurity) and Y_{DV} (digital vision)

X_{DRC} (digital risks and cybersecurity)	Rank X_{DRC}	Y_{DV} (digital vision)	Rank Y_{DV}
2	2	2	2
3	6.5	2	2
3	6.5	3	6.5
3	6.5	3	6.5
3	6.5	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
4	21	4	21
5	36.5	4	21
5	36.5	4	21
5	36.5	5	36.5
5	36.5	5	36.5
5	36.5	5	36.5
Sum	420.5	Sum	399.5

These data were sufficient to use the formula calculating the empirical value of the criterion – the Mann-Whitney criterion. The calculation results are shown in y Eq. C1.

$$U_{emp2} = 20 \times 20 + 20 \times \frac{20+1}{2} - 420.5 = 189.5 \quad [C1]$$

The hypothesis H_0 about the insignificant difference between the samples was accepted only if $U_{cr}<U_{emp}$. Otherwise, the H_0 hypothesis was rejected and the difference between the sample scores was considered significant.

From the table of critical values for the Mann-Whitney test, the values of the critical point (U_{cr}) for significance levels (α) 0.05 and 0.01 were found: $U_{cr}(0.05) = 127$; $U_{cr}(0.01) = 105$.

Since $U_{cr}<U_{emp2}$ the null hypothesis (H_0 was accepted with a probability of 95% – the difference in samples levels could be considered not significant. The digital strategy considers the digital risks of the organisation's ecosystem and vice versa.

Appendix D

Confirmation of hypothesis #4

During the survey, respondents evaluated their level of two digital skills – adaptability and flexibility, self-awareness, gender equality, cultural, and religious awareness. Based on these results, the fourth research hypothesis was formed:

Null hypothesis (H_0): The level of adaptability and flexibility of managers wasn't lower than their level of signs in the group – self-awareness, gender equality, cultural and religious awareness.

Alternative hypothesis (H_1): The level of adaptability and flexibility of managers was lower than their level of signs in the group – self-awareness, gender equality, cultural and religious awareness.

The hypothesis was tested for reliability using the Mann-Whitney test – Eq. 12.

The comparison in Table D2 showed that the value of the choice of X_{SGCR} (self-awareness, gender equality, cultural and religious awareness) was higher than that of the choice of Y_{AF} (adaptability and flexibility), therefore, the choice of X_{SGCR} was considered the first. The goal was to determine whether the difference between scores could be considered significant.

The first stage was ranking the table. When ranking, two samples were combined into one. Ranks were assigned in order of increasing value of the measured value, that is, the lowest rank corresponded to the lowest score. In the case of coincidence of rank for several respondents, the rank of such a score was considered the arithmetic mean of their positions occupied by these scores when they were arranged in ascending order.

Since there were related ranks (the same rank number) of the 1st row in the matrix, their reformation was done. Reshaping of ranks was carried out without changing the importance of the rank, i.e., the corresponding ratios – greater, less, or equal – had to be preserved between the rank numbers. The rank was not set above 1 and below a value equal to the number of parameters (40). The transformation of ranks is given in Table D1.

Table D1. Rank transformation (self-awareness, gender equality, cultural and religious awareness; adaptability, and flexibility)

Numbers of places in the ordered sequence	Position of factors in the respondent's (expert's) assessment	New ranks
1	3	3
2	3	3
3	3	3
4	3	3
5	3	3
6	4	14.5
7	4	14.5
8	4	14.5
9	4	14.5
10	4	14.5
11	4	14.5
12	4	14.5
13	4	14.5
14	4	14.5
15	4	14.5
16	4	14.5
17	4	14.5
18	4	14.5
19	4	14.5
20	4	14.5
21	4	14.5
22	4	14.5
23	4	14.5
24	5	32
25	5	32
26	5	32
27	5	32
28	5	32
29	5	32
30	5	32
31	5	32
32	5	32
33	5	32
34	5	32
35	5	32
36	5	32
37	5	32
38	5	32
39	5	32
40	5	32

The process of leveling the ranking results followed similarly to the process of leveling the ranking results that were applied to confirm the second and third hypothesis. The ranking results for the selection value of X_{SGCR} (self-awareness, gender equality, cultural and religious awareness) and Y_{AF} (adaptability and flexibility) are shown in Table D2.

Table D2. Ranking results for the value of choice X_{SGCR} (self-awareness, gender equality, cultural and religious awareness) and Y_{AF} (adaptability and flexibility)

X_{SGCR}	Rank X_{SGCR}	Y_{AF}	Rank Y_{AF}
3	3	3	3
3	3	3	3
3	3	4	14.5
4	14.5	4	14.5
4	14.5	4	14.5
4	14.5	4	14.5
4	14.5	4	14.5
4	14.5	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	4	14.5
5	32	5	32
5	32	5	32
5	32	5	32
5	32	5	32
5	32	5	32
Sum	465.5	Sum	354.5

These data were sufficient to use the formula calculating the empirical value of the criterion – the Mann-Whitney criterion. The calculation results are shown in Eq. D1.

$$U_{emp3} = 20 \times 20 + 20 \times \frac{20+1}{2} - 465.5 = 144.5 \quad [D1]$$

The hypothesis H_0 about the insignificant difference between the samples was accepted only if $U_{cr}<U_{emp}$. Otherwise, the H_0 hypothesis was rejected and the difference between the sample scores was considered significant.

From the table of critical values for the Mann-Whitney test, the values of the critical point (U_{cr}) for significance levels (α) 0.05 and 0.01 were found: $U_{cr}(0.05) = 127$; $U_{cr}(0.01) = 105$.

Since $U_{cr}<U_{emp3}$ the null hypothesis (H_0) was accepted with a probability of 95% – the difference in samples levels could be considered not significant. Increasing the level of adaptability and flexibility of a manager leads to an increase in his/her self-awareness, gender equality, cultural and religious awareness, and vice versa.