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Digital Approaches to Public Election Management in the Era of E-Democracy

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ABSTRACT

In the context of increasing global migration and growing risks to citizens' security, the development of electronic voting systems as part of the digitalization of election management is becoming increasingly urgent. Digital technologies create new opportunities to modernize electoral processes, improve accessibility for voters, and enhance the efficiency of public administration. The purpose of this study was to examine the experience of digitalizing public election management within the broader framework of e-democracy. The research methodology is based on a qualitative approach and focuses on the analysis of European countries' experiences in implementing digital tools for election management. Particular attention is given to the institutional, technological, and political conditions that influence the adoption of e-voting systems. The results indicate that several European states have successfully implemented digital instruments for election administration, particularly where a high level of e-participation already exists. Estonia provides a prominent example, demonstrating the effectiveness of online voting through the use of secure electronic identification, personal computers, and dedicated web applications within a well-organized electoral infrastructure. At the same time, experiences in France, Norway, Finland, and Switzerland reveal political, technical, and administrative barriers that have limited or suspended pilot e-voting initiatives. The cases of Belgium, Ireland, Germany, and the Netherlands further highlight the need for thorough preparation, strong public trust, and effective mechanisms to address security risks and technical failures.

***Keywords*:** elections, election management bodies (EMBs), electoral management methods, e-government, e-democracy, e-voting.

Introduction

A new form of e-democracy is emerging in different countries around the world, based on cooperation and discussion between government and citizens. This model promotes inclusive, open, and transparent policy-making processes using online tools and information and communication technologies (ICTs). New technologies are seen as tools for e-participation of citizens, which is important for ensuring legitimacy, transparency, and trust in public administration, promoting more meaningful and direct interaction between government and the population (Mariani et al., 2024). Electronic voting (e-voting) is one of the tools of digital democracy, the use of which makes it possible to simplify the processes of selecting candidates, strengthen the participation of citizens in the political life of the country, and use resources more efficiently. E-voting is becoming an important means of increasing the level of e-participation of

citizens in different countries. According to OECD data, within OECD member countries, the level of turnout in elections has decreased, which reflects the limited e-participation of the population in electoral processes. In the period from the early 1990s to the early 2020s, participation in parliamentary elections in OECD countries decreased on average from 75% to 65%. Voter turnout among 18 to 24-year olds is, on average, 12% lower than among adults aged 25 to 50 inclusive (OECD, 2024).

After the global coronavirus pandemic in 2020, e-voting as an alternative way of exercising the right to vote creates new opportunities for ensuring democracy and increasing the level of e-participation of citizens (Ehin et al., 2022). Discussions have begun to arise in various European countries on the possibilities of using e-voting for holding elections (Alown, Kiraz & Bingol, 2025). At the same time, in some countries, the testing processes of e-voting have been suspended due to risks to the security and integrity of the electoral process (Ehin et al., 2022). In the context of the growing importance of e-democracy for ensuring the legitimacy, transparency, and openness of public authorities, it is important to develop various digital tools for managing electoral processes.

In this study, public sector innovation is defined as the use of digital technologies and e-governance tools to modernize election administration, improve accessibility, and increase the efficiency of electoral processes. This definition emphasizes systemic transformation of administrative procedures rather than individual technological improvements. Election management bodies (EMBs) refer to the institutions responsible for organizing and conducting elections, while electoral management methods refer to the set of administrative and digital procedures used to ensure the transparency, security and efficiency of the electoral process. This terminology is consistent with international standards.

Literature Review

The growth of interest in the issues of e-democracy in 2010–2025 is due to the processes of digitalization of public administration and the transition from traditional models of political activity to digital ones (including voting in elections, citizen participation in political processes) (Macintosh, 2007).

The increasing use of ICTs to transform public administration has contributed to the development of e-governance, a new management paradigm that relies on digital tools to improve efficiency (Sundberg, 2019), increase government accountability, and make public services more accessible (Spirakis, Spiraki & Nikolopoulos, 2009). E-democracy, as a component of e-governance, involves developing technological innovations to enhance and expand the capabilities of democratic institutions in the provision of public services and in the creation of functional democratic processes (Päivärinta and Sæbø, 2006). These include open communication with citizens, accountability and information, decision-making after voting, and electronic public dialogue (Lee, Chang & Berry, 2011; Spirakis, Spiraki & Nikolopoulos, 2009). In the context of digitalization, e-democracy serves as the basis for citizens' active participation in solving complex public problems, taking their interests into account. At the same time, some studies indicate that e-government initiatives offer little benefit to citizens, leading to a

weakening of democracy (Sundberg, 2019). This situation is due to citizens' low trust in political systems in conditions of instability (Shat & Pimenidis, 2017).

The introduction of electronic voting has become an urgent task for governments amid growing geopolitical challenges and threats, economic crises, increased migration, and local conflicts, all of which pose a threat to citizens' security (Shat & Pimenidis, 2017). Safe access to elections and the realization of citizens' right to participate in the democratic process have driven the digitalization of public election management (Shat & Pimenidis, 2017).

Electronic voting is considered a form of digital direct democracy (Hilbert, 2009), a means to simplify electoral processes (Fauzi and Habibi, 2023), or a tool of e-democracy (Musiał-Karg, 2014). The earliest theoretical studies of this concept primarily focused on its advantages. Since 2010, approaches to electronic voting have changed due to numerous implementation challenges (Hilbert, 2009). The example of Indonesia demonstrates the initial stage of e-voting in conditions of limited and uneven distribution of citizens' electronic identification (Fauzi and Habibi, 2023). For its full implementation, it is necessary to build supporting infrastructure, ensure the reliability of the legal framework, and provide appropriate educational training for the population (Fauzi and Habibi, 2023). In contrast, Estonia's example demonstrates the effectiveness of introducing e-voting, supported by legal frameworks and ongoing technological updates, which contributed to a high level of voter trust (Ehin et al., 2022).

Methodology

The research is based on a qualitative design and case study of European countries in the application of digital tools in public management of electoral processes. The sample of European countries was formed according to the criteria of availability of qualitative data on experience and practice in the application of technologies for electronic elections at the local and national levels. The data were collected from official sources of the European Commission (European Commission, 2021), academic peer-reviewed studies for 2015–2025, which highlight the practice of e-voting, the main obstacles, and challenges in the implementation of e-voting. To highlight the Ukrainian experience in election management in the context of digitalization and the prospects for the introduction of e-voting, secondary data from the Council of Europe Office in Ukraine's study on risks and opportunities (Council of Europe Office in Ukraine, 2024) were analyzed. The principles of objectivity, transparency, openness, and accessibility of secondary sources of information were applied to collect data. The dynamics of the E-Participation Index for the top European nations from 2014 to 2024 were examined to identify patterns in the growth of e-democracy as a crucial component of the digitalization of election administration (United Nations, n. d.).

For the study, peer-reviewed scientific publications for 2015–2025 were selected, which directly cover the practice of electronic voting, obstacles and challenges to its implementation in European countries. The selection of sources was carried out according to the following criteria:

a) the availability of qualitative or quantitative data on e-voting;

b) mentioning institutional, technological or political aspects of implementation;

c) relevance to the topic of public governance of electoral processes.

The countries for the case study (Estonia, France, Norway, Finland, Switzerland, Belgium, Ireland, Germany, the Netherlands, Italy) were selected on the basis of the presence of documented experience of pilot or permanent e-voting systems. Additionally, data from the European Commission (European Commission, 2021), the UN (E-Participation Index) and the report of the Council of Europe Office in Ukraine (2024) were analyzed.

Results

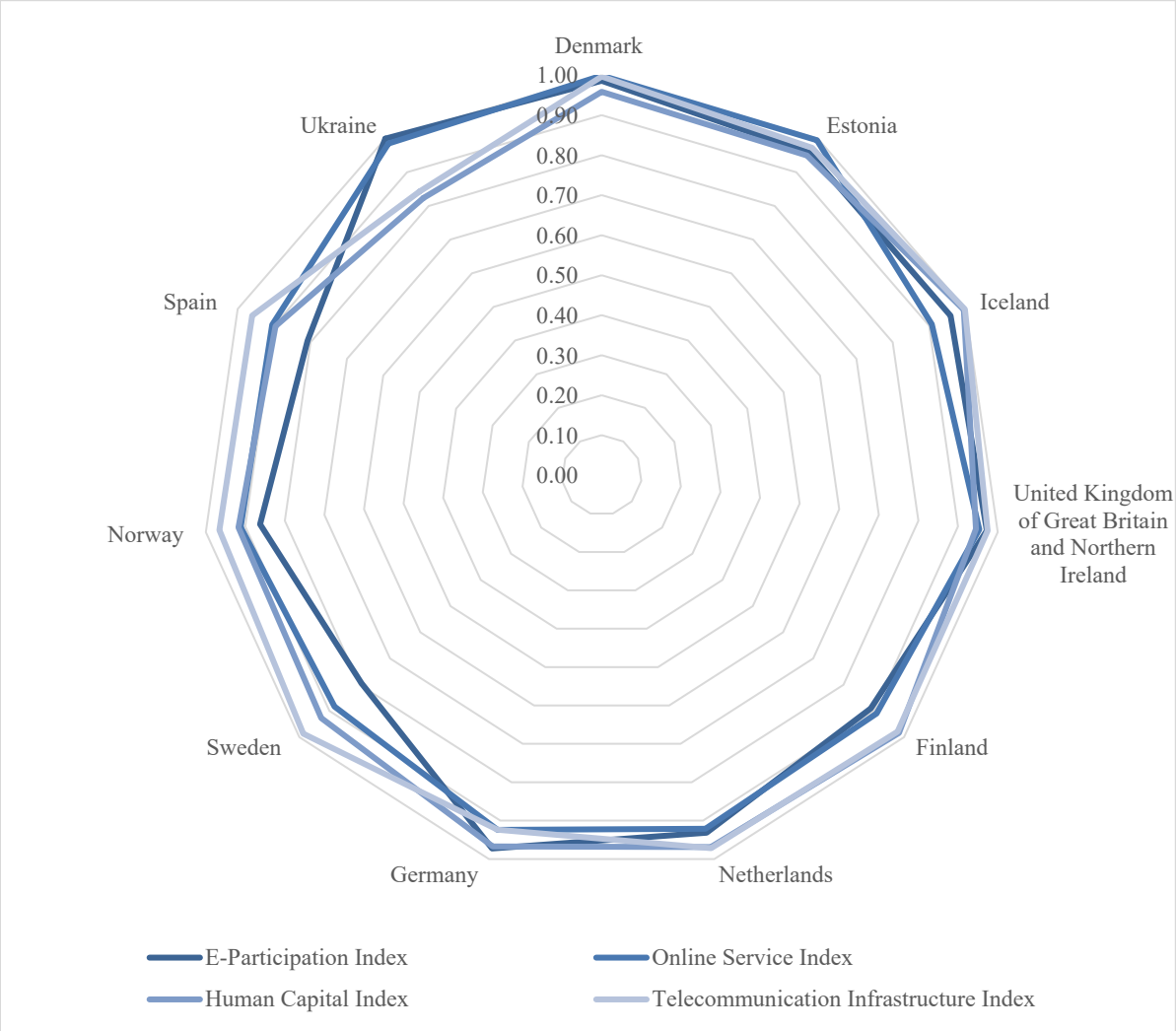
This article contributes to the research on public sector innovation by analyzing the European experience with e-voting and identifying the institutional, technological and political factors necessary for successful digital election management. The results presented below illustrate these factors through a cross-national comparison.

In most European countries, there is a high level of electronic participation of citizens in political processes in the context of the development of human capital, telecommunications infrastructure, and online services (Figure 1). The analysis of the European e-Participation Index 2014–2024 shows that over the past ten years, significant improvements have been made in the processes of digital interaction between government and citizens. In 2014, the leading countries were France, the Netherlands, the United Kingdom, Finland, Spain, Norway, Sweden, Estonia, Denmark, and Iceland. Over the past ten years, European countries have seen changes in the interaction between government and the population, which have become possible as a result of improving public governance through e-participation. Denmark, Estonia, Iceland, the UK, Finland, the Netherlands, Germany, and Sweden lead the way in e-participation development in 2024. In these countries, Ukraine ranked 30th in the e-governance ranking with high indicators of citizen e-participation, development of online services, human capital, and ICT infrastructure in 2024. Compared to 2014, Ukraine has significantly improved the level of citizen e-participation in political processes due to the digitalization of public administration in the field of public service provision. Ukraine's e-participation index was 0.43 points in 2014, and increased significantly during 2020–2024 in the context of financing the activities of the Ministry of Digital Transformation of Ukraine, as the central executive body responsible for digitalization policy.

Estonia's experience with e-voting deserves more detailed coverage. Estonia became the first country in the world to introduce online voting in national elections on 1 January 2005. All voters have the right to vote from any personal computer connected to the Internet, regardless of their location. As of 2023, the country has held five parliamentary elections, five local elections and three elections to the European Parliament using e-voting (Estonian Internet voting, 2019). Online voting has become widespread: in the most recent European Parliament elections in 2019, almost half of all ballots cast were electronic. An analysis of the Estonian experience provides valuable material for any country considering the possibility of introducing online voting or, more broadly, the potential of technology to transform democracy (Ehin et al., 2022).

In addition to Estonia, e-voting was introduced for local referendums in Norway in the 2011 elections and for the 2013 parliamentary elections (Bull, Gjøsteen & Nore, 2018), for local elections in the UK in 2002–2007, and for legislative elections in overseas territories in France since 2012 (Table 1). In Norway, shortcomings such as incorrect printing of ballot papers due to technical failures and incorrectly configured certificates have directly and indirectly contributed to lost votes and negative interactions with citizens (Bull, Gjøsteen & Nore, 2018).

Figure 1: E-Participation Index of Europe's Leading States in 2024



Source: United Nations, n. d.

In Figure 1, the lines correspond to the following countries (from top to bottom by e-Participation Index value in 2024): Denmark, Estonia, Iceland, United Kingdom, Finland, Netherlands, Germany, Sweden. Detailed color and marker designations for each country are provided in the graph legend. As can be seen from Figure 1, the countries of Northern and Western Europe demonstrate a consistently high level of e-participation, which creates a favorable basis for the digitalization of electoral procedures. Table 1 systematizes the main digital technologies used in the management of the electoral process in European countries.

Table 1: Digital technologies for public election management in European countries

Technology	Application	Countries of application	Year of implementation
Electronic voter registers	Creation of digital voter registries that are integrated into government databases to automate voter registration processes	Finland, Latvia, Hungary, Slovenia	2000s
Electronic identification	For authentication of voters and provision them with access to election services	Estonia, Finland, Germany, Portugal	2002
Electronic voting	Remote voting via the Internet using e-identification and cryptographic protection	Estonia, Norway*, France*, the United Kingdom*, Switzerland*	2005
Electronic machines	For voting at polling stations	Ireland, Germany, Italy	2000s
Electronic vote counting	Digitalization of vote counting	Malta, Ireland	2009
Digital platforms	Centralized collection, processing and publication of voting results in real time	The Netherlands, Norway, Romania	2010s
Cybersecurity systems	Using cybersecurity systems, cryptography, and security protocols to ensure the security of electoral processes	Estonia, EU countries	2007

Source: Compiled by the author based on data (European Commission, 2021)
Note: *Experimental introduction of e-voting

France has partially implemented e-voting in certain political contexts, such as public consultations; however, it is not used for national or local elections. Internet voting has not been used in any presidential elections in France; however, it has been used for primary elections and intra-party elections, or for voting by French citizens living abroad in consular and legislative elections (Dandoy and Kernalegenn, 2021). At the same time, the authorities have noted a decline in voter turnout over the past few years, especially in the 2021 regional elections (Guéraiche, 2023). Citizens believe that online voting is important for the population, but it is rejected for political reasons (Von Nostitz et al., 2024). According to the findings (Guéraiche, 2023), there is no evidence in a political context that e-voting increases voter turnout, given the increased likelihood of blank or blank ballots.

In Finland, an e-voting pilot project was implemented in three small municipalities for the 2008 local elections. Additionally, the user interface's complexity led to lost votes, requiring human intervention. A 2017 assessment of the feasibility of online voting in Finland showed the following risks: cyberattacks, insufficient confidentiality, and over-reliance on election system administrators (Alown, Kiraz & Bingol 2025).

Switzerland was a leading country in online voting and testing in this area from 2003 to 2019. However, its prevalence in the country remains low. This is due to the “cautious” approach to the introduction of e-voting in the country (Germann, 2021).

In Belgium, e-voting using electronic machines was introduced in 150 Flemish and 9 German-speaking cities and Brussels for the EU and national elections. The e-voting procedure involves voters registering at polling stations, receiving their cards, and starting the electronic

machines. After voting at the ballot boxes, voters receive a receipt confirming their vote, which needs to be scanned to prevent multiple vote registrations (European Commission, 2021).

Table 2. Comparative analysis of e-voting cases by institutional, technological and political dimensions

Country	Institutional Dimension (Legal Framework, Organizational Readiness)	Technological Dimension (Cybersecurity, System Reliability)	Political Dimension (Public Trust, Political Will)	Outcome
Estonia	Well-developed legal framework, full integration of electronic identification, clearly organized electoral process	Reliable e-identification system, continuous technological updates, high level of cybersecurity	High level of public trust, broad political consensus	**Successful** (continuous use since 2005)
France	Partial legal regulation (only for overseas voters), absence of a unified model	Pilot solutions, limited scalability	Low political will at the national level, concerns about legitimacy	**Limited use** (not for nationwide elections)
Norway	Pilot projects conducted (2011–2013), but administrative shortcomings were identified	Technical failures (incorrect ballot printing, certificate-related issues)	Loss of public trust due to negative experience	**Suspended** after pilot projects
Finland	Pilot project in 2008 in three municipalities, lack of a comprehensive framework for permanent implementation	Complex user interface (resulting in lost votes), risks of cyberattacks and confidential data breaches	Cautious governmental position, negative expert assessment	**Suspended**
Switzerland	Long-term pilot projects (2003–2019), but no nationwide implementation	Cryptographic vulnerabilities identified during system testing	Cautious approach accompanied by extensive public debate	**Suspended** in 2019
Belgium	Voting machines used in selected regions, partial regulatory framework	Technical problems with voting machines, insufficient transparency of the voting process	Limited public trust, continued reliance on traditional voting procedures	**Limited local use**
Germany	Pilot use of voting machines, followed by a Constitutional Court ruling declaring them unconstitutional due to insufficient transparency	Voting machines did not provide opportunities for independent auditing and verification	Political decision to discontinue use following the court ruling	**Suspended**
Netherlands	Widespread use of voting machines (1990–2007), followed by security concerns	Voting machines were compromised (2006); experts rejected proposals to reintroduce them	Loss of public trust, return to paper ballots	**Suspended** since 2007
Italy	Limited pilot project in 2006; new regulations adopted in 2023 (six guiding principles)	Web-based applications compatible with multiple devices, stringent requirements for secure digital identification	Experimental approach, plans to expand implementation for overseas voters	**Preparation for large-scale implementation**

Source: compiled by the author based on a generalization of European experience.

In the context of the war in Ukraine, the issue of introducing e-voting in national elections after the end of hostilities has become relevant. In this regard, a study of the risks and opportunities for its introduction was conducted by the Council of Europe Office in Ukraine in 2024. The results indicate the need for constitutional changes in the event of the introduction of e-voting, the presence of legislative restrictions, the need to develop a pilot project, and its

testing. Ukraine does not have the appropriate legal framework, organizational, and methodological foundations for the introduction of e-voting immediately after the war, characterized by a high level of risks in this area of management (Council of Europe Office in Ukraine, 2024).

In 2002, the Irish government spent 54 million EUR on electronic voting machines; however, they were never used in the country due to security risks. Germany also purchased e-voting machines as part of a pilot project, which was halted after the Constitutional Court ruled that they were not transparent and open enough. In April 2006, electronic machines were used in the Italian national elections as part of a pilot project. It involved 3,000 voters and four polling stations. The project was successful for Italy (European Commission, 2021).

From the late 1990s to early 2007, electronic machines were the most widely used method of e-voting in most regions of the Netherlands. However, security issues in 2006 led to challenges in voting, and the country returned to the traditional method of voting (European Commission, 2021). In 2013, a new Committee proposed the reintroduction of printer-based e-voting, but experts gave negative recommendations for their application in vote counting (European Commission, 2021).

To systematize the results, Table 2 presents a comparative analysis of cases along three key dimensions identified in the study: institutional (regulatory and legal framework, organizational readiness), technological (cybersecurity, system reliability), and political (public trust, political will). This approach allows us to identify common prerequisites for successful and unsuccessful experiences of implementing e-voting.

Discussion

The analysis of the advantages and disadvantages of digital tools for public management of electoral processes shows that their use contributes to increasing the efficiency of the administration of electoral processes, their automation, and the level of accessibility for citizens to exercise their right to vote. Additional advantages of using technologies include speeding up the voting process, processing results, and ensuring transparency and accountability. At the same time, the main disadvantages of using digital tools in electoral processes relate to the risks of losing personal data, the need to update state registers and technologies, the development of citizens' digital skills, and ensuring a high level of public trust in technologies (Table 3).

Security risks are one of the main obstacles holding back the adoption of e-voting and related technologies. For example, after the introduction of pilot projects for online voting in Switzerland between 2003 and 2019, e-voting was suspended due to security concerns (Ehin et al., 2022). In particular, cryptographic weaknesses were identified in the Swiss e-voting system (Culnane et al., 2019).

Table 3: Digital tools for public governance and election administration: advantages and disadvantages

Technology	Advantages	Disadvantages
Electronic voter registers	Automation of registration processes, accuracy of voter data, integration with state registries	Risks of personal data leakage, dependence on the quality of data in state registers, the need for constant updating of state registers
Electronic identification	Reliable voter authentication, the possibility of remote participation in elections, integration with other digital technologies	The need for a high level of digital literacy among voters, technical barriers to use by certain groups of voters
Electronic voting	Increasing accessibility, convenience for voters, remote voting, reducing costs for organizing elections	Risks of cyberattacks, the difficulty of ensuring transparency of electoral processes and full trust of citizens
Electronic machines	Speed of voting processes, reduction of invalid ballots, automation of counting	High purchase and maintenance costs, limited verification of results
Electronic vote counting	Speed of obtaining results, reduction of human errors, increase of efficiency of processing of election data	Dependence on software, risks of data manipulation, need for independent audit
Digital platforms	Prompt publication of results, increased transparency of the electoral process, effective communication with voters	Risks of cyberattacks, spread of disinformation, need for reliable digital infrastructure
Cybersecurity systems	Protecting electoral systems from cyberattacks, ensuring the integrity of electoral data, and increasing trust in electoral processes and technologies	High implementation cost, need for constant technology updates, complexity of cyber risk management

Source: Compiled by the author based on data from Alown, Kiraz & Bingol (2025) and Ehin et al. (2022)

The issue of implementing electronic voting is the most discussed in the literature. From the point of view of voters, such systems are acceptable, safe, and convenient. At the same time, from the point of view of developers of pilot projects and policies, they are challenging to scale, to guarantee the privacy and security of voter information and election outcomes, and to get rid of issues like double voting or technical malfunctions that could arise during online elections (Guéraiche, 2023).

It is also important to pay attention to the methodology of public election management in the context of the digitalization of society. The experience of Italy demonstrates the importance of rules and administrative procedures for conducting e-voting. The most recent model of e-voting rules has been proposed in Italy. The Italian government plans to implement this e-participation tool from 2023 for EU and national elections, referendums. The first stage is planned to implement a pilot project for voters abroad or those temporarily residing outside the country. For this purpose, recommendations were adopted by the main responsible Italian agency (Italian Ministry of the Interior), which contain six principles (European Commission, 2021). These include the obligations of administrative authorities to ensure the security, accessibility, and functionality of e-voting. The recommendations include the development of mechanisms and guarantees to avoid the error of repeated e-voting by the same voter. Voters must use personal voting devices or have access to a polling station. E-voting is carried out through a web

application that operates over the Internet and is compatible with digital devices. Voter identification must be carried out through digital identification technology with at least a significant level of security. An independent body is responsible for monitoring the functioning of e-voting procedures (European Commission, 2021).

Given the experience of European countries in introducing e-voting in electoral processes, it is important to identify ways to improve the methodology of public election management based on e-governance tools. Governments of countries planning to introduce these technologies should determine the approach to managing electoral processes using digital technologies. A risk-based approach to public management allows taking into account all possible risks associated with security, confidentiality, access of different categories of the population to e-voting, the level of citizen trust, administrative obstacles, and infrastructure. When planning pilot e-voting projects at the local and national levels, it is worth considering all the risks that may arise at the stages of their implementation and scaling. Taking existing risks into account is important for developing further actions and mechanisms to eliminate them in the electoral process, to create a positive experience of interaction between the authorities and the population. Public management of elections should be based on the principles of their effective, transparent, and open administration, clear functionality of e-voting, and ensuring security and accessibility of e-voting for different segments of the population.

Conclusion

In European countries, the implementation of digital tools for public election management is at an early stage, despite the high level of development of e-democracy. This means that there are high risks in the application of digital tools for public administration in this area, which require immediate response and the development of mechanisms to guarantee citizen participation in elections in the event of technical failures. The political context has significantly affected the ability to effectively implement and manage e-voting in European countries.

The introduction of electronic voting as one of the most common tools of election management depends significantly on internal factors (effectiveness of political decisions, management methodology, ability of management entities to manage risks in this area) and external factors (level of public trust in this digital tool, development of digital literacy, demographic structure of the population, development of the country's ICT infrastructure). The experience of Estonia demonstrates the effectiveness of conducting e-voting under the conditions of an appropriate legal framework, organization, and preparation for elections using digital tools. The practice of France, Norway, Finland, Switzerland, and Belgium indicates political, technical, and administrative obstacles to the implementation of pilot projects in this area of management. Insufficiently effective public management of e-voting in terms of legal support, organization, preparation of pilot projects, and management methodology became the main reasons for the suspension of its implementation. Thus, the successful implementation of electronic voting as one of the most common election management tools significantly depends on a complex of internal (effectiveness of political decisions, management methodology, ability of management entities to take risks into account) and external (level of public trust, digital literacy,

demographic structure, development of ICT infrastructure) factors, which is confirmed by the experience of both successful and suspended cases.

The researched innovation serves an important public good: it supports democratic participation, accessible elections, transparency, and more effective public administration, thereby strengthening the legitimacy of democratic institutions.

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The ChatGPT-4 Turbo model was used to prepare the manuscript solely as an auxiliary tool for language editing, stylistic correction, and readability enhancement. The scientific results, analytical conclusions, and conceptual positions were formulated by the authors without the use of artificial intelligence.

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