

Unequal AI readiness: institutional and digital disparities in e-government across the European Union

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ABSTRACT

Artificial Intelligence (AI) is increasingly being integrated into public governance, enabling more adaptive, predictive, and autonomous public services. Despite its potential, the extent to which European Union member states are ready to adopt AI in electronic government remains under-explored. To address this gap, AI readiness across European Union countries is assessed and clustered based on institutional and technological conditions. Using secondary data from Eurostat and the European Commission's electronic Government Benchmark, exploratory factor analysis reveals two latent dimensions: Digital Skills and Electronic Government Engagement, and Transparency and Electronic Government Service Availability. These dimensions are used as inputs for hierarchical and k-means clustering, resulting in six distinct country groups reflecting varying profiles of AI readiness. Our findings suggest that effective AI integration is associated with both institutional capacity and citizen preparedness, linking digital divide patterns to AI readiness levels. This study provides a comparative, data-driven assessment of AI readiness across the European Union, identifying latent dimensions that can inform targeted policy interventions and support inclusive digital transformation.

1. Introduction

Artificial Intelligence (AI) is increasingly shaping modern society, and the public sector is no exception (Madan and Ashok, 2023). Some tasks and decisions that were once carried out by humans are now being supported by AI systems (Zuiderwijk et al., 2021). The motivation behind this shift is clear: governments seek to streamline administrative processes, enhance service delivery, improve decision-making, and strengthen citizen engagement (Twizeyimana and Andersson, 2019).

While earlier waves of e-government focused on digitization and access, AI introduces the potential for more adaptive, predictive, and autonomous public services, reshaping citizen–state interactions (van Noordt and Misuraca, 2022b). These technologies are gradually being explored in domains such as decision support, transportation, public health, and law enforcement. A joint study by EY and Microsoft (2020) reflects this momentum, with 65% of surveyed European public organizations acknowledging the value of AI and 67% reporting adoption of at least one application. Nonetheless, the prospective integration of AI into public governance raises significant concerns, particularly around privacy, accountability, discrimination, and the potential for surveillance and manipulation (Janssen et al., 2020).

Despite longstanding academic interest in AI (van Noordt and Misuraca, 2022a; Wirtz and Müller, 2019), much of the literature remains rooted in technical and computer science domains (Aoki, 2020), with limited engagement from a governance perspective

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(Zuiderwijk et al., 2021). Within the smaller body of research that addresses AI implementation in governments, most contributions remain largely conceptual, focusing on potential challenges, risks, or implementation barriers (Wirtz et al., 2019; Zuiderwijk et al., 2021), rather than offering empirical insights (Sun and Medaglia, 2019).

While institutional and organizational factors have been acknowledged in the literature on digital government and AI adoption (e.g., Bailey and Barley (2020); Kuziemiński and Misuraca (2020)), research often remains conceptual, fragmented, or limited to single-country analyses. In this study, we address this gap by examining how such governance-related factors contribute to measurable differences in AI readiness across EU member states. Building on the prior work on institutional and organizational capacity in digital government, we operationalize these concepts using harmonized cross-country proxies drawn from Eurostat and the European Commission's eGovernment Benchmark, suitable for comparative assessment. Institutional factors are understood in a broad sense to encompass structural and normative features of governance, such as the stability of administrative arrangements, the transparency of public decision-making, and societal expectations around accountability and trust in government. Organizational factors, by contrast, refer to the internal capacities of public administrations, including their ability to deliver integrated digital services, coordinate across departments, and adapt workflows to emerging technologies. Although often interdependent, distinguishing between these dimensions helps clarify how broader governance frameworks and agency-level capabilities together shape the conditions under which AI can be effectively adopted in the public sector.

This benchmark-based operationalization aligns with prior cross-country research that empirically assesses digital government capacity using harmonized indicators and established benchmarking frameworks (Lnenicka et al., 2024; Zídková et al., 2024). Eurostat provides harmonized demand-side indicators capturing citizens' digital skills and engagement with online public services, whereas the European Commission's eGovernment Benchmark captures supply-side service maturity (e.g., online availability, transparency, and key enablers). These measures are also consistent with broader practice benchmarks such as the United Nations E-government development index (UN EGDI) (United Nations, 2022) and the Digital Economy and Society Index (DESI) (European Commission, 2024), but are more directly aligned with the e-government service context examined in this study. For example, Lnenicka et al. (2024) analyze EU member states using major digital government benchmarks (including DESI- and EGDI-type indices) and apply quantitative techniques to compare and classify national performance over time. Similarly, Zídková et al. (2024) justify the selection of e-government benchmark measures by contrasting them with alternative practice-based indices, illustrating how such indicators are used in EU-wide empirical analysis. Together, these studies support the use of Eurostat indicators and the European Commission's eGovernment Benchmark as comparable, practice-based proxies suitable for assessing readiness-related differences across EU member states.

Against this background, we focus on the following research question: *To what extent are EU member states ready to integrate AI into their e-government systems?* Our objective is to provide an empirical assessment of AI readiness in a European comparative context. To this end, we use secondary data from Eurostat and the European Commission's eGovernment Benchmark. Exploratory factor analysis is applied to identify latent dimensions of readiness, followed by hierarchical and k-means clustering to group countries based on shared digital characteristics (Hair et al., 2019). This methodology enables us to map overall readiness patterns and reveal distinct national profiles. The findings contribute to the limited empirical literature on AI in the public sector and offer insights to inform more tailored digital policy strategies across the EU.

2. Theoretical background

2.1. E-government in the age of artificial intelligence

AI-enabled transformation represents a new phase in the evolution of e-government, introducing structural and governance implications that extend beyond earlier ICT-based reforms. Early e-government efforts prioritized web presence and administrative efficiency through static information and basic transactional services (Gil-Garcia and Martinez-Moyano, 2007). With the rise of machine learning applications, personalized services, predictive analytics, and real-time decision-making are increasingly shaping public service delivery, marking a shift beyond basic Information and Communication Technologies (ICTs) and positioning AI as a core pillar of Government 3.0 (Straub et al., 2023).

In the context of e-government, AI is understood as a range of technological systems, with varying degrees of autonomy, that learn from data, recognize patterns, and make decisions to support public services, achieving specific goals and adapting over time (Zuiderwijk et al., 2021). Rather than being a simple technical upgrade, it is envisioned as a core mechanism for e-government systems, paving the way for new modes of governance in domains such as health, taxation, and welfare.

From a readiness perspective, applied use cases show how some governments are beginning to operationalize AI. In taxation, AI is being explored to enhance efficiency through automated auditing and fraud detection (Mökander and Schroeder, 2024). AI-driven analytics enable governments to develop proactive policies based on data pattern recognition (Lepeniotti et al., 2021). In social services, AI-based tools can facilitate early intervention by identifying vulnerable individuals and optimizing resource allocation (Koivisto et al., 2023). The healthcare sector stands to benefit from AI through predictive models for disease detection, diagnostics, and personalized treatment (Sun and Medaglia, 2019).

Despite the acknowledged benefits of AI in the public sector, a paradox persists: while its necessity is widely recognized, its large-scale implementation remains limited (Zuiderwijk et al., 2021). Scholars emphasize AI's potential to revolutionize governance, yet its adoption is hindered by regulatory, ethical, and legal challenges, alongside a lack of empirical validation (Trajkovski, 2024). These limitations underscore the need to move beyond adoption narratives toward a structured assessment of the conditions that enable or constrain AI integration in e-government. In this sense, AI readiness emerges as a necessary conceptual lens for examining the

institutional, organizational, and governance capacities that precede large-scale deployment.

2.2. Digital inequalities as a structural backdrop to AI readiness in E-government

Digital inequality research provides a foundational theoretical stream for understanding structural variation in digital government capacity. Rather than constituting a direct dimension of AI readiness, digital divides function as a contextual condition that shapes both citizen capability and institutional preparedness across countries. The concept of the digital divide has evolved significantly since its early definition by the OECD as “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to their opportunities to access ICTs and to their use of the Internet for a wide variety of activities” (Organisation for Economic Co-operation and Development (OECD), 2001). While initially framed as a binary issue of internet access, scholarship increasingly recognizes the divide as multidimensional, encompassing disparities in infrastructure, digital literacy, and engagement with technologies (Ferro et al., 2011; Scheerder et al., 2017).

Although earlier work had already noted that wealthier and more integrated EU member states advanced more quickly in digital transformation (Cruz-Jesus et al., 2012), recent studies suggest that these gaps have evolved into more complex divides encompassing not only access and skills but also digital outcomes (Ferreira et al., 2021; van Deursen and Helsper, 2015). In the EU context, these digital divides manifest unevenly across regions and social groups. Northern and Western European countries, such as Denmark, Finland, and the Netherlands, have heavily invested in ICT infrastructure and digital service enablers (e.g., eID and interoperable online services), alongside inclusive policies, which foster higher levels of digital skills and usage (Grishchenko, 2024).

By contrast, Southern and Eastern member states, including Bulgaria, Romania, and Greece, continue to face lower levels of digital literacy and slower progress in e-government adoption, often linked to educational disparities and weaker institutional capacity (Profiroiu et al., 2024; Švarc et al., 2021). Moreover, recent evidence shows that divides are not only national but also spatially embedded, with differences in digital access, usage, and outcomes observable within countries and cities (Ferreira et al., 2021). Such inequalities risk compounding social and economic disparities and are likely to shape the extent to which citizens and institutions are prepared to engage with AI-enabled public services.

Building on digital divide research, e-readiness frameworks translate structural inequalities into measurable dimensions of governmental preparedness. These frameworks operationalize readiness through factors such as infrastructure, human capital, and governance capacity, thereby offering an institutional bridge between digital inequality and AI readiness. Frameworks in the literature commonly emphasize infrastructure, digital skills, organizational capacity, and policy and regulatory conditions as key enablers (Sheoran and Vij, 2022). Later research expanded this view by highlighting multiple levels of digital engagement: inequalities in access, usage, and outcomes each shape the effectiveness of digital transformation (Ferreira et al., 2021). Empirical evidence from Europe further illustrates how these readiness dimensions remain uneven, with persistent gaps in digital skills and institutional capacity across member states (Grishchenko, 2024).

Yet, many existing e-readiness indices and frameworks have been criticized for being overly focused on infrastructure and access, while overlooking less tangible but equally important dimensions such as governance quality, trust, and institutional resilience (Sheoran and Vij, 2022). Science and technology studies research further demonstrates that infrastructures are socio-technical and political formations through which expertise, state authority, and modes of governance are produced and contested, rather than neutral technical backbones (Barry, 2020; Rowland and Passoth, 2015). These perspectives indicate that although e-readiness provides a useful point of departure, the growing integration of AI into public services calls for a broader conception of AI readiness that incorporates transparency, explainability, and organizational transformation.

The emergence of artificial intelligence (AI) in public services introduces a new and less clearly defined barrier to readiness: the AI divide. Although still under conceptual development (Wang et al., 2024a), this notion extends the logic of the digital divide by incorporating not only disparities in access to infrastructure and the skills required to use technologies, but also the ability of citizens and institutions to derive meaningful outcomes from opaque, algorithmically driven systems (Carter et al., 2020; Zuidervijk et al., 2021). Unlike earlier digital transitions, AI technologies heighten concerns around transparency, explainability, and fairness, as citizens' trust and willingness to engage are shaped by whether algorithmic decisions are understandable, accountable, and perceived as legitimate (Aoki et al., 2024; Laux et al., 2024). This makes institutional readiness, through governance structures, regulatory oversight, and organizational adaptation, an essential component of AI adoption (Ali and Khan, 2025; Holmström, 2022; Uren and Edwards, 2023).

Recent work further shows that public administrations require deep socio-technical transformations to integrate AI effectively, including changes in data governance, organizational processes, and employee capabilities (Tangi et al., 2025). Within the EU, such challenges are unevenly distributed: while some member states are experimenting with algorithm registers and transparency mechanisms, others face weaker regulatory capacity and limited institutional expertise (Van Noordt and Misuraca, 2022a). As such, the AI divide risks compounding existing digital inequalities by adding novel barriers of trust, explainability, and governance, thereby deepening disparities in e-government readiness across the Union.

Taken together, this stream of research indicates that AI readiness cannot be reduced to technological availability or adoption intensity alone. Rather, it reflects the interaction between citizen-side capabilities (digital skills and engagement) and institutional-side governance conditions (service maturity, transparency, and regulatory capacity). These dual dimensions provide the structural foundation for conceptualizing AI readiness as a multidimensional capacity that precedes deployment and shapes cross-country variation in AI integration within e-government.

2.3. AI adoption in E-government: context and implementation considerations

AI adoption research constitutes a related but distinct theoretical stream that examines the drivers, benefits, and constraints associated with implementing AI in public administration. While adoption studies focus on implementation processes and outcomes, they do not necessarily explain the structural conditions that precede and enable large-scale AI integration. This stream therefore helps clarify why a readiness perspective is necessary. AI adoption in e-government is increasingly being pursued as part of broad digital reform, with a large number of AI projects moving beyond the pilot stage. In Estonia, for instance, the Agricultural Registers and Information Board uses SATIKAS—an AI system leveraging computer vision and satellite data—to monitor land mowing compliance, reducing costly manual inspections. Other countries, such as Belgium and Sweden, have implemented similar initiatives in childcare inspections and recruitment (European Commission. Joint Research Centre., 2020, pp. 42-45).

Several interrelated drivers are behind this growing orientation toward AI. Governments seek to increase efficiency and reduce administrative burden by automating high-volume, rule-based processes—enabling cost savings, faster service, and responsiveness (Wirtz et al., 2019; Zuiderwijk et al., 2021). Strategic and political alignment further accelerates uptake. These initiatives are also shaped by broader goals of public value creation. Governments anticipate that AI could improve service delivery, enhance transparency, personalization, and citizen trust—though citizen involvement and support in AI design remain limited (Zuiderwijk et al., 2021).

AI adoption in governments is associated with a broad range of potential benefits. A synthesis by Zuiderwijk et al. (2021), drawing on 26 studies, categorizes these benefits across key domains. In regard to decision-making, AI enables the automation of routine processes, reduces administrative burden, and improves the accuracy of public decisions. Gains in efficiency and performance include error reduction, relief from repetitive tasks (Kuziemski and Misuraca, 2020) and improved operational efficiency in e-government systems. Van Kolfsoohten & Van Oirschot (2024) emphasize contributions to healthcare, with AI enabling personalized services through chatbots (Androusoopoulou et al., 2019) and tailored public announcements. At a broader societal level, AI is seen to contribute to enhanced security, citizen trust and satisfaction (Kuziemski and Misuraca, 2020), and human-machine collaboration in complex administrative contexts. Finally, the study identifies sustainability-related benefits, such as smarter environmental monitoring and more efficient resource use in domains like energy.

Nonetheless, it is also accompanied by several challenges spanning technical, ethical, organizational, and societal domains (Sun and Medaglia, 2019). Data quality and reliability remain problematic, as incomplete, biased, or poorly structured datasets can produce skewed outcomes and reduce trust in algorithmic decisions (Wirtz et al., 2019). Public institutions often face internal resistance to innovation and limited capacity to manage AI projects and outdated governance structures (Sun and Medaglia, 2019; Wirtz et al., 2020). A persistent skills gap further slows progress as public organizations often lack in-house AI expertise, and cross-sector collaboration is hindered by uneven digital literacy. Even when systems are deployed, their opacity often complicates interpretation and decision-making (Kuziemski and Misuraca, 2020).

Ethical, political, and legal concerns include algorithmic bias, lack of transparency, threats to privacy, accountability and the erosion of human agency in automated decisions (Wirtz et al., 2019). Broader societal issues—such as growing inequality, unrealistic expectations, job displacement, and economic constraints due to the cost of infrastructure and uncertain return on investment—further complicate implementation in resource-constrained public settings (Medaglia et al., 2023). Citizen-side uptake of digital government initiatives is also shaped by privacy and trust concerns, which can constrain adoption even when services are technically available (Lin et al., 2021).

Overall, adoption studies show that AI integration in public administration is driven by efficiency goals and public value ambitions, yet constrained by substantial socio-technical, organizational, and governance challenges. At the same time, this literature primarily examines implementation dynamics rather than the pre-existing citizen-level and institutional capacities that condition successful deployment across countries. Distinguishing adoption from readiness therefore allows the present study to focus analytically on the structural and governance foundations that make AI integration feasible. Recent cross-national evidence similarly points to a growing “government AI adoption divide,” where variation in enabling conditions and institutional capacity contributes to uneven AI uptake across countries (Wang et al., 2024a,b).

Table 1
Concept-centric synthesis of research streams informing AI readiness in e-government.

Articles	Digital inequalities/disparities in e-government	AI readiness in e-government	AI adoption in e-government	Citizen capability/engagement	Governance & Service Maturity
(Wang et al., 2024a,b)	X	X	X		X
(Paroški, 2025)		X			X
(Lnenicka and Nikiforova, 2021)					X
(Lin et al., 2021)		X	X	X	X
(Pang et al., 2014)		X		X	X
(Straub et al., 2023)		X	X		X
(Van Noordt and Misuraca, 2022a)		X	X		X
(Tangi et al., 2023)			X		X
(Zuiderwijk et al., 2021)			X	X	X
(Wirtz et al., 2019)			X		X

Following Webster and Watson (2002) concept-centric approach to literature reviews, Table 1 presents a concept matrix mapping representative studies to the key concepts structuring the theoretical background.

2.4. AI readiness and disparities in the EU

Jöhnk et al. (2021) define organizational AI readiness as the preparedness of public or private institutions to implement changes involving AI technologies. Complementarily, digital readiness refers to “an organization’s state of being prepared for effective production or adoption, assimilation, and exploitation of digital technologies” (Lokuge et al., 2019). In line with these definitions, AI readiness in e-government can be understood as the capacity of public administrations to effectively integrate AI technologies into their operations and service delivery systems, even before deployment occurs. In this study, AI readiness is treated as the central analytical construct, serving as the basis for the empirical assessment of disparities in e-government capacity across EU member states. This capability-oriented view is consistent with Information Systems research on public-sector value creation, which conceptualizes digital resources as translating into service delivery and public engagement capabilities within public organizations (Pang et al., 2014).

Measuring this readiness is inherently multidimensional and context specific. Existing literature identifies several core dimensions of e-readiness that are also applicable to AI readiness in the public sector (Jöhnk et al., 2021; Lokuge et al., 2019; Socol and Iuga, 2024). These include: (1) human capital, which refers to digital and technical skills among public employees and citizens; (2) digital governance capacity, which encompasses institutional capability for strategy, coordination, and change management; (3) ICT infrastructure, such as broadband access and core IT systems; (4) regulatory and ethical frameworks, including laws, standards, and accountability mechanisms; and (5) economic condition, capturing the availability of financial resources for digital transformation. These dimensions represent both technical and institutional preconditions for adoption and are used in various national and international assessments of digital maturity.

In infrastructure studies, the term is commonly understood as a multi-layered sociotechnical foundation rather than only physical hardware: it involves the coupling of physical systems with the data, information, and communications that flow through them, and the term is also used to describe enabling institutional arrangements such as legal frameworks and social institutions. Information infrastructure work likewise emphasizes that infrastructure extends beyond “tubes and wires” to include organizational and normative elements that make systems function in practice (Bowker et al., 2009). Accordingly, in this paper we distinguish between (i) technical ICT infrastructure, (ii) digital service infrastructure (e.g., shared service enablers such as eID, interoperability mechanisms, and digitised document workflows), and (iii) institutional infrastructure (governance capacity) (e.g., coordination mechanisms, transparency/accountability practices, and regulatory capacity).

UNESCO’s Readiness Assessment Methodology provides a normative tool to guide the ethical and effective integration of AI in government settings (UNESCO, 2023). However, disparities in AI readiness persist across EU member states (Foffano et al., 2023). Northern and Western European countries such as Finland and the Netherlands consistently rank among the top performers, while Eastern and Southern states—such as Latvia, Bulgaria, and Romania—lag significantly behind (Oxford Insights, 2024). These disparities map onto the structured dimensions mentioned above: lower performance is often linked to insufficient ICT and digital service infrastructure, lack of digitally skilled personnel, weak coordination mechanisms, and constrained financial or institutional resources (Mitrović, 2020; Papadimitriou et al., 2017).

While existing readiness indices offer valuable insights, their indicators remain broad and are not tailored to the specific context of e-government operations. Related work also notes that benchmarking approaches differ in scope and operationalization across prominent EU and UN assessment frameworks, reinforcing the importance of clarifying how readiness is measured in comparative analyses (Paroški, 2025). Moreover, although European policies provide a regulatory foundation, their impact depends on national implementation, which varies significantly. This reinforces the need for readiness-focused empirical evidence. Addressing this gap, the

Table 2
Name, description, literature support, domain, and side of AI readiness variables used

Variable	Description	Theoretical support	Domain	Side
eGov_Int	Internet use: interaction with public authorities (%)	(Kulal et al., 2024; Troitiño et al., 2024; Van Noordt and Misuraca, 2022a)	Organizational	Demand
eID_PubUse	Individuals who used their eID to access public services in their country (%)	(Andrade, 2012; Schneider et al., 2020; Van Dijck and Jacobs, 2020)	Technological & institutional	Demand
DigSkills	Individuals with above basic overall digital skills (%)	(Bélanger and Carter, 2009; Ebberts et al., 2016; Kulal et al., 2024)	Technological	Demand
HealthInfo	Individuals using the internet for seeking health-related information (%)	(Alvarez-Galvez et al., 2020; Merkel and Hess, 2020; Tavares, 2020; Van Kolschooten, 2023)	Technological & organizational	Demand
InternetBank	Individuals using the internet for internet banking (%)	(Takieddine and Sun, 2015; Yera et al., 2020)	Technological & organizational	Demand
Transparency	Openness in service delivery, design, and personal data use by government (0-100)	(Janssen and Van Den Hoven, 2015; Matheus and Janssen, 2020)	Institutional	Supply
OnAvab	Share of online availability of public services (0-100)	(Al-Ansi et al., 2024; Koh et al., 2008; Kulal et al., 2024; Li, 2011)	Technological & organizational	Supply
eDoc	Use of e-documents for submitting or downloading service-related files (0-100)	(Androutsopoulou et al., 2019; Larsson, 2021; Madariaga et al., 2019)	Technological & organizational	Supply
PreFilled	Share of online forms with user data pre-filled by the government (0-100)	(Androutsopoulou et al., 2019; Larsson, 2021; Madariaga et al., 2019; Scholta et al., 2019, 2020)	Technological & organizational	Supply

present study explores AI readiness within e-government, aiming to generate comparative insights and support the design of more targeted digital policy interventions.

To synthesize the theoretical background, we conceptualize AI readiness in e-government as a multidimensional capacity that precedes deployment and depends on complementary conditions: (i) demand-side citizen capability/engagement and (ii) supply-side service maturity/governance enablers. This is particularly important because transparency is not only a policy principle but also a design feature of digital public services that supports accountable and legitimacy, both conditions that become more salient when AI systems are introduced into public decision-making (Lnenicka and Nikiforova, 2021). On the demand side, readiness relates to citizens' digital skills and engagement with digital services, which shape the feasibility and effective uptake of AI-enabled public services. On the supply side, readiness relates to the maturity of digital public services and the governance enablers that support accountable implementation, such as transparency and service design features that enable automation. In line with this conceptual framing, the empirical strategy measures AI readiness using harmonised demand-side indicators from Eurostat and supply-side indicators from the European Commission's eGovernment Benchmark, as reported in Table 2. Digital inequalities are treated as a contextual backdrop that helps interpret cross-country differences in these readiness components rather than as a direct readiness dimension.

3. Methodology

3.1. AI readiness indicators and data sources

A set of proxy indicators is used to measure Artificial Intelligence readiness in electronic government at a EU level, drawn from two complementary sources: (1) Eurostat for the first five indicators, and (2) the European Commission's electronic Government Benchmark Report for the remaining four (European Commission, 2023; Eurostat, 2022). While most indicators refer to 2022, two of them (DigSkills and eID_Pub_Use) are taken from 2023, as these are the most recent values available. Using the most up-to-date data ensures completeness, and prior trend analyses show limited year-to-year variability in these indicators, so their inclusion does not affect the comparability of results. Our study adopts AI readiness indicators measured at the level of the entire population. Table 2 builds on the synthesis presented in Table 1 by mapping the two conceptual components of AI readiness discussed in Section 2 to the proxy indicators used in the analysis.

Willingness, system usability, and relevance are all prerequisites for effective e-government (Kulal et al., 2024; Troitiño et al., 2024; Van Noordt and Misuraca, 2022a), therefore a must for AI adoption. Hence, interactions with public authorities were included (eGov_Int). The use of electronic identification to access public services (eID_Pub_Use) enables secure and personalized systems (Van Dijck and Jacobs, 2020) while promoting EU integration (Andrade, 2012), another necessity of AI deployment in e-government. As public services become increasingly digital, the ability to navigate online platforms become crucial. Citizens' ability to interact effectively with digital systems has been shown to influence both trust in those systems and their overall usability (Bélangier and Carter, 2009; Ebbers et al., 2016).

The European Commission (2010) identifies eHealth and eBanking as "some of the most innovative and online services". Seeking health-related information online signals familiarity with digital tools in sensitive domains as well as trust in information systems - implying potential for AI-based healthcare adoption (Alvarez-Galvez et al., 2020; Tavares, 2020). Meanwhile, frequent use of internet banking reflects trust in secure digital transactions and parallels core features of AI-enabled public services, including authentication and automation (Yera et al., 2020). Therefore, DigSkills, HealthInfo, and InternetBank were considered as key indicators of this study.

Fatima et al. (2020) identify challenges related to the transparency and auditability of learning algorithms, particularly in public service contexts. Consequently, (Transparency) is included as a pillar of ethical and effective AI adoption in e-government, given its role in fostering trust, enabling accountability, and enhancing citizens' readiness to engage with AI systems (Janssen and Van Den Hoven, 2015).

The online availability of public services is a baseline indicator of digital readiness, capturing both infrastructure and institutional capability to deliver services digitally. Higher online availability enables the deployment of AI systems and automated decision-making, as these technologies depend on digitized service environments (Al-Ansi et al., 2024; Koh et al., 2008). Therefore, a measure of online availability of public services (OnAvab) was included in the study. The use of electronic documents to submit or access service-related files reflects a government's capacity to digitize administrative processes, reduce bureaucratic friction, and enable automation. As a foundational layer for AI integration, e-documents support interoperability and efficient, user-centred, public service delivery (Larsson, 2021; Madariaga et al., 2019). Similarly, automatically reusing citizen data to complete service fields is a critical indicator of AI readiness in e-government as it reduces user burden, streamlines service delivery, and reflects automated governance - exemplified by the "one-stop shop" model (Scholta et al., 2019). For that reason, both (eDoc), and (PreFilled) were included.

A missing value was found (eID_PubUse - France) due to confidentiality reasons. To address this, the median was used for imputation, minimizing distortion from potential outliers or skewed data. All variables were then standardized to ensure comparability and eliminate scale bias, as required for reliable factor extraction. The dataset (see Appendix A) already provides some preliminary insights, even at this early stage. Notably, there are significant disparities among EU countries across various indicators related to digital government services and digital skills. For instance, while Finland shows strong performances—scoring 91.13 in eGovernment interaction and 85.94 in eID public use—Romania lags behind with just 14.00 and 1.58 in those same areas, respectively. The average eID public use across the EU is 44.15, yet over half of the countries fall significantly below this benchmark. These early findings suggest clear regional gaps that could influence the broader success of EU-wide digital strategies.

3.2. Factor analysis

To uncover the underlying dimensions of AI readiness in e-government, an Exploratory Factor Analysis (EFA) was conducted. This statistical technique reduces complex, multidimensional data into a smaller set of interpretable factors, making latent patterns easier to identify and analyse (Cruz-Jesus et al., 2016). Before conducting EFA, several assumptions must be verified. First, the variables should exhibit moderate intercorrelation—otherwise, the factor solution may be weak or unreliable. As noted by Hair et al. (2019), “specific items that correlate highly are assumed to be a member of that broader dimension.” Second, the dataset must demonstrate suitability for factor analysis, which can be confirmed through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett’s test of sphericity. If these conditions are met, the next step involves determining the optimal number of factors—ideally, the smallest number that retains the maximum amount of explanatory power. Finally, the extracted factors are interpreted based on their loadings.

The correlation matrix (see Appendix B) indicates that each variable has at least one correlation coefficient of 0.50 or higher with another variable. Overall, correlations range from 0.32 to 0.89, suggesting moderate to strong associations without extreme or anomalous values. This pattern suggests that the variables are statistically interrelated and likely reflect different dimensions of the same underlying phenomenon.

Data suitability was also confirmed by the KMO test, which returned a score of 0.80—classified as “meritorious” according to Kaiser (1974). Bartlett’s test of sphericity also produced a statistically significant result ($p < 0.001$), indicating sufficient correlations among variables for factor analysis.

To determine the number of factors to retain, the analysis applied the Kaiser criterion—selecting factors with eigenvalues greater than one—and visual inspection of the scree plot. These approaches consistently supported a two-factor solution. A varimax rotation was applied to improve interpretability while maintaining orthogonality, under the assumption that the underlying dimensions are independent (Hair et al., 2019). A promax (oblique) rotation was also tested, yielding a similar factor structure, which further confirmed the robustness of the two-factor solution. Together, the two extracted factors explain 100% of the total variance, with Factor 1 accounting for 50.7% and Factor 2 for 49.3%, indicating a balanced representation of the data structure.

To assess internal consistency, Cronbach’s Alpha was calculated for each factor. This measure evaluates how reliably the grouped variables represent a single construct. Following Hair et al. (2019), who recommend a minimum threshold of 0.70, both Factor 1 ($\alpha = 0.94$) and Factor 2 ($\alpha = 0.90$) demonstrate excellent reliability, as seen in Table 3.

The final step of the factor analysis involves interpreting the factors based on their loadings — that is, identifying which variables contribute most to each underlying dimension. The rotated factor structure indicates that AI readiness can be explained by two dimensions: one with the group of variables related to citizen skills and interactions, and another with variables related to government services. The first factor, *Digital Skills and E-Government Engagement*, reflects the population’s digital capabilities and interaction with e-services, including digital skills and frequency of online government use. The second factor, *Transparency and E-Government Service Availability*, captures institutional readiness, including openness, user-centric design, and accessibility of digital services. To position each country within this two-dimensional space, factor scores were computed using the regression method, generating a standardized estimate of performance along each latent dimension. These scores were then used as the input for the cluster analysis. Fig. 1 illustrates the country coordinates derived from these factor scores.

3.3. Cluster analysis

To complement the findings from factor analysis and identify patterns in AI readiness among EU countries, cluster analysis was conducted. This approach groups countries based on similarities in their performance across the two extracted factors, resulting in distinct country groups that reflect varying levels of digital skills and institutional preparedness for AI integration in e-government.

The clustering process followed a two-step approach. To determine the optimal number of clusters, the elbow method was first applied to k-means clustering on the factor scores. This analysis indicated a six-cluster solution as the most appropriate (see Appendix C). Building on this, Ward’s method was applied on the standardized factor scores. Ward’s method was chosen due to its

Table 3
Factor loadings, variance, and cronbach’s alpha.

Rotation: Varimax		
	Factor 1	Factor 2
DigSkills	0.826553	0.348888
HealthInfo	0.801235	0.202481
InternetBank	0.798684	0.467675
eGov_Int	0.762162	0.512873
eID_PubUse	0.625215	0.571771
Transparency	0.246539	0.883727
PreFilled	0.334555	0.756217
OnAvab	0.376541	0.745076
eDoc	0.350153	0.679452
Variance (%)	50,23%	49,76%
Variance Total		100%
Cronbach’s α	0.94	0.90

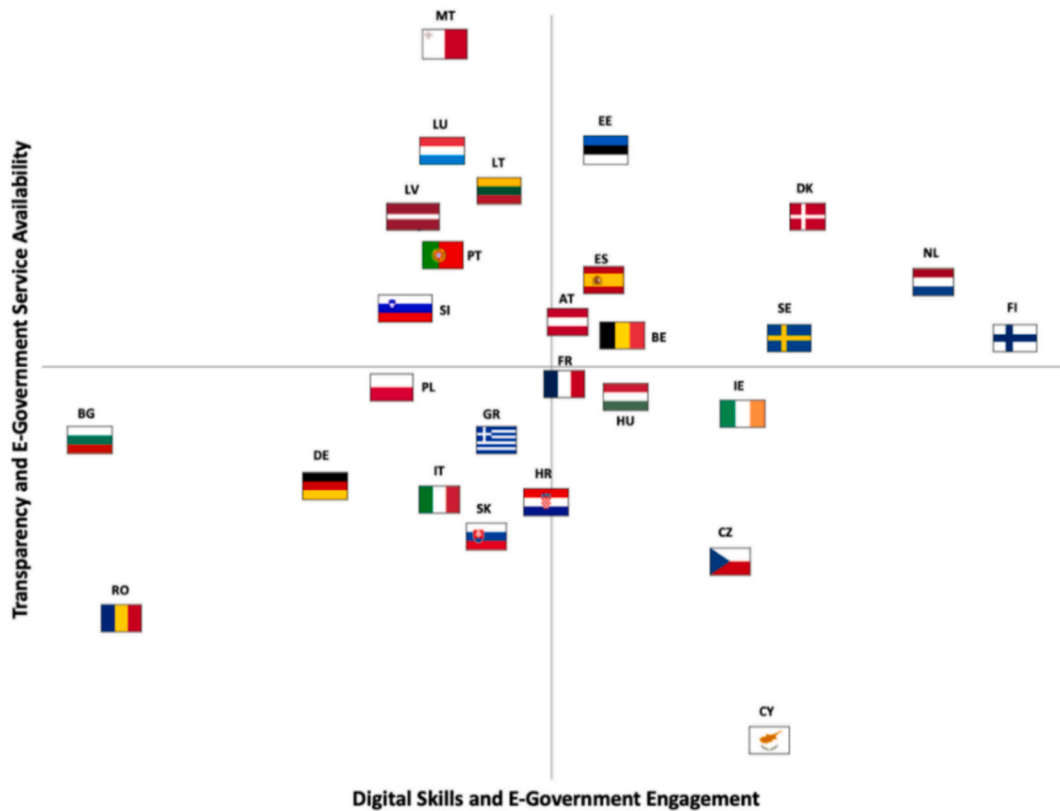


Fig. 1. Country coordinates extracted from Factor Scores.

capacity to minimize variance within clusters and generate well-defined, compact groups (Hair et al., 2019)—a feature that supports its frequent application in public sector analyses (e.g. Hafeezallah et al., 2024; Kaltoft et al., 2013). Fig. 2 shows the hierarchical clustering dendrogram.

Next, k-means clustering was applied using the centroids derived from the Ward solution as initialization seeds, to ensure coherence. The final cluster distribution, shown in Fig. 3, maps EU countries across the two extracted factors: *Digital Skills and E-Government Engagement* (Factor 1), and *Transparency and E-Government Service Availability* (Factor 2).

Finally, a Kruskal-Wallis test was applied to each factor to assess whether significant differences existed across the six clusters. Results confirmed that both Factor 1 and Factor 2 scores varied significantly between groups ($p < 0.001$), reinforcing the validity of the clustering structure. Table 4 shows the descriptive statistics of each cluster.

4. Discussion

AI readiness in the EU e-government systems appears to have two underlying and independent dimensions: *Digital Skills and E-Government Engagement* and *Transparency and E-Government Service Availability*. From the analysis of nine variables, we were able to extract six clusters that reveal different approaches to digital transformation in e-government. Our first finding is that this divide does exist, and some of the member-states placements converge with previous analyses—i.e., the digital divide.

Bulgaria and Romania underperform across both dimensions, with extremely low levels of digital skills, suggesting systemic barriers to AI readiness. The inclusion of these Central and Eastern European countries aligns with known regional disparities (Surubaru, 2017; Tutak and Brodny, 2024). Hence, we call these countries “AI Readiness Laggards”. These countries may focus on promoting digital capacity-building across society.

Croatia, Germany, Greece, Italy, Poland, Slovakia, and Slovenia occupy a middle-ground position in the AI readiness landscape. These countries show moderate levels of digital skills and citizen engagement but underperform in institutional transparency and the availability of AI-enabled services, suggesting that technical capacity alone is insufficient. Germany’s presence—while surprising given its economic strength—may be explained by its decentralized governance, stringent data protection norms, and slow electronic ID adoption (Molnár-Gábor, 2018).

Slovenia, while sharing these challenges, offers a promising case of institutional investment. Its *National Programme for the Promotion of the Development and Use of Artificial Intelligence until 2025* outlines targeted initiatives to ensure AI-supported services are broadly accessible and trusted. Public-facing platforms such as e-Uprava, GOV.si, and SPOT are identified as strategic gateways for

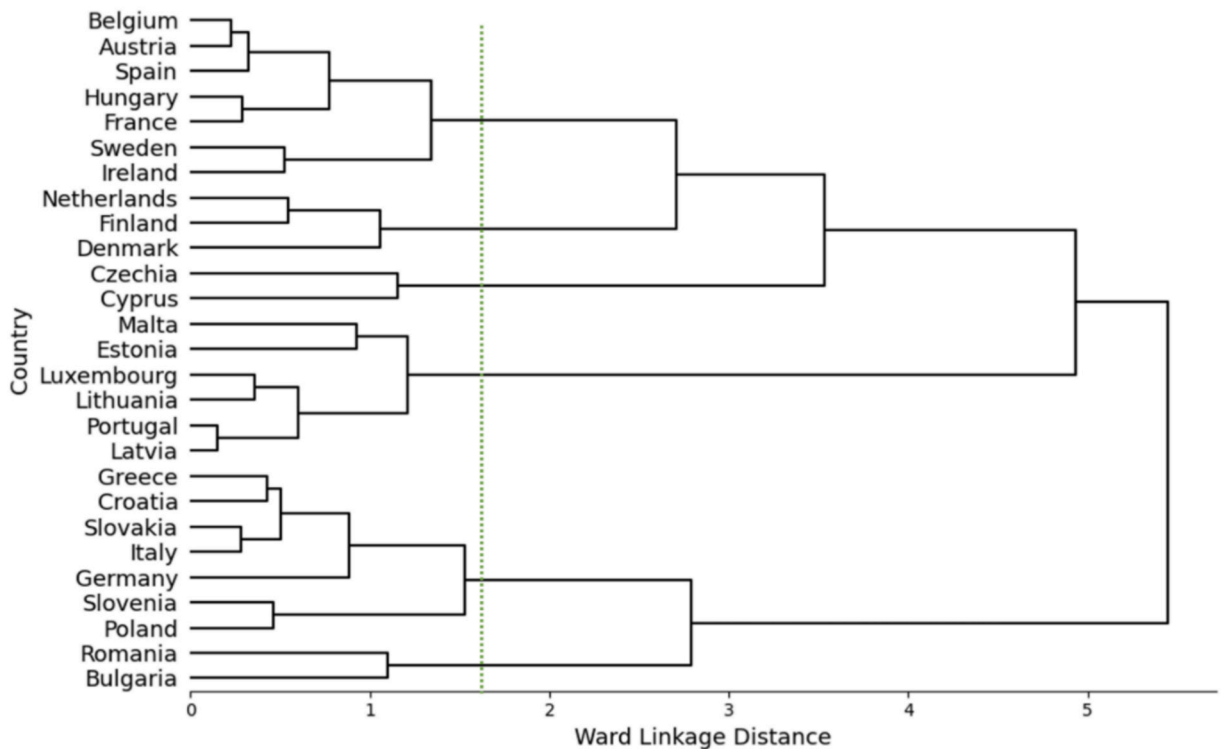


Fig. 2. Hierarchical clustering dendrogram (Ward's method, Euclidean distance) based on standardized factor scores for 27 EU countries.

deploying AI-powered tools across public services. Moreover, shared data spaces and robust infrastructure to support the scalability and reliability of such services are being developed (Ministry of Public Administration, Republic of Slovenia, 2021, p.37). Poland, similarly, has embraced an ambitious trajectory. In its draft national digital strategy, the government aims for 85% of citizens to possess at least basic digital skills and 80% of public offices to use AI technologies by 2035 (Ministerstwo Cyfryzacji, 2024). We call this group the “Emerging Performers”.

While digital engagement is foundational, AI readiness in e-government also depends on institutional transparency, service availability, and trust-enhancing mechanisms (Matheus and Janssen, 2020). Countries scoring lower on this factor would benefit from national and EU-backed policies that ensure AI systems used in public service are explainable, accessible, and citizen-oriented.

Estonia, Latvia, Lithuania, Luxembourg, Malta, and Portugal reflect moderate digital readiness, with slightly lower-than-average digital skills but strong transparency and service availability, suggesting an emphasis on accessibility and user-centric design. Malta's outstanding performance in institutional transparency may highlight different strategic emphases for different countries. Hence, we call this cluster the “Service-Driven”.

Cyprus and Czechia show an outstanding case of high digital skills paired with extremely low e-service transparency and openness, indicating governance barriers to implementation - similar to other digitally ready yet institutionally constrained contexts (Mergel et al., 2019). We call this cluster “Digitally Capable, Institutionally Lagging”.

Denmark, Finland, and the Netherlands, lead in both digital skills and transparency, pointing to a reinforcing cycle between citizen competence and institutional readiness. Therefore, we call these “AI-Ready Leaders”. The Digital Economy and Society Index corroborates this, with these three countries ranking among the top in digital public services and human capital (European Commission, 2024). Their strong alignment with Digital Decade 2030 goals (Eurostat, 2022) positions them as leaders in systemic integration. Denmark, a benchmark country, introduced a common ethical foundation to guide AI deployment across sectors under its 2019 National Strategy for Artificial Intelligence. The goal is to ensure ethical principles—including transparency, responsibility, and explainability—are systematically embedded in all public AI systems (Agency for Digital Government, 2019, p.28). Complementing this, the government set a concrete target to increase citizen trust in digital services: raising confidence in public data handling from 83% to 90% by 2024 (Agency for Digital Government, 2019, p.25). Compared to the “AI Readiness Laggards” and the “Service-Driven” group, this group exemplifies the dual necessity of infrastructure and digital literacy.

Austria, Belgium, France, Hungary, Ireland, Spain and Sweden demonstrate balanced performance across both dimensions, scoring consistently above the mean on both factors, without being extreme outliers in either direction. Sweden and Ireland stand out for their digital service engagement, while Austria and Belgium maintain moderate profiles. Though not facing severe deficits like the AI Readiness Laggards, these countries risk lagging without continuous investment in digital skills, cross-sector collaboration, and AI implementation—key to meeting Digital Decade objectives. Therefore, we call these the “Balanced Readiness Performers”.

To complement our findings, we reflect on how they relate to Gross Domestic Product (GDP) per capita and government-sector R&D

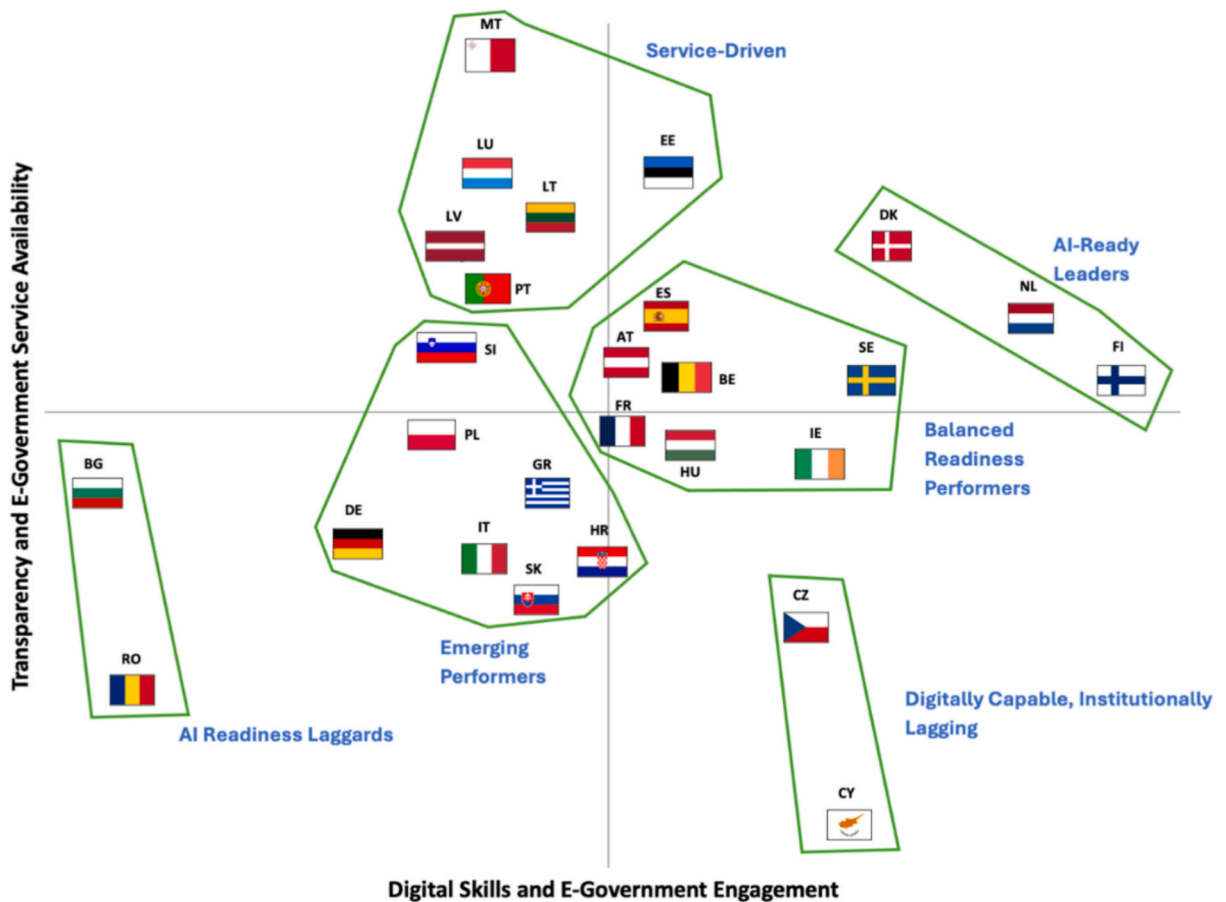


Fig. 3. Cluster analysis based on EU countries' factor scores.

Table 4
Descriptive statistics of each cluster.

Cluster name	Factor 1		Factor 2	
	Mean	Std. Deviation	Mean	Std. Deviation
AI Readiness Laggards	-2.01	0.1	-1.01	0.77
Emerging Performers	-0.50	0.32	-0.53	0.47
Service-Driven	-0.35	0.31	1.19	0.43
Digitally Capable, Institutionally Lagging	0.88	0.14	-1.73	0.80
AI-Ready Leaders	1.66	0.47	0.52	0.37
Balanced Readiness Performers	0.41	0.39	0.07	0.30
Kruskal-Wallis (p-value)	0.0005		0.0007	

expenditure (GERD), using Eurostat data from 2022. This reflection shows that our AI readiness clusters are only partially aligned with economic indicators. For instance, Denmark, Finland, and Sweden combine high GDP per capita with advanced readiness, suggesting a reinforcing effect of resources and governance. In contrast, Luxembourg and Ireland—among the wealthiest EU members—do not appear as AI-Ready Leaders, indicating that institutional and governance limitations can outweigh economic advantages. Malta, with exceptionally low GERD, performs well in transparency and service availability, suggesting that strategic institutional choices can compensate for limited resources. Germany, despite very high government R&D expenditure, shows only moderate readiness, likely due to regulatory constraints and fragmented implementation. These examples suggest that while financial resources and research investment are enabling factors, they are not sufficient to explain differences in AI readiness. Institutional design, governance capacity, and citizen digital skills appear more decisive, pointing to the need for EU and national strategies that go beyond economic investment to foster trust, inclusion, and effective AI-supported public service delivery.

5. Implications for policy

To build AI readiness in e-government, action must target both Factor 1: Digital Skills and E-Government Engagement and Factor 2: Transparency and E-Government Service Availability. For countries such as Bulgaria and Romania, foundational improvements are required. National digital agencies should roll out citizen-focused digital literacy programs, especially for low-income and elderly populations, while also simplifying digital service interfaces. Local governments can complement these efforts by embedding guided support into public institutions, including digital helpdesks or “AI kiosks” into public institutions. At the civil service level, training providers should develop AI-focused modules, targeting both technical use and ethical awareness, focusing on promoting internal capacity.

In countries where digital skill levels are not matched by transparency or institutional openness, action should focus on explainability and user trust. Municipalities should implement AI transparency dashboards and offer explanations for algorithmic decisions in public services, further increasing trust due to proof of value. Citizen involvement through participatory testing of e-services can also strengthen engagement. Conversely, countries with strong transparency but weaker digital skills should invest in user-centric support, expanding education and training programs for both citizens and public employees. Peer-led digital literacy programs and digital support hubs can ensure that excluded groups are not left behind as AI tools are adopted.

For digital frontrunners, the priority lies in sustaining innovation while maintaining high transparency standards. These frontrunners should act as benchmarks, serving as knowledge hubs and fostering cross-national cooperation to strengthen digital governance across the EU. Mechanisms such as innovation grants and joint development of open-source tools can accelerate learning and diffusion. Supporting less advanced member states through joint pilot projects or shadowing programs would enhance system-wide alignment and help close the AI e-government readiness gap.

6. Limitations and future research

This study presents several limitations that should be acknowledged. First, the analysis relies on a limited set of nine proxy indicators which, while relevant, cannot fully reflect the multidimensional nature of AI readiness in e-government. This limitation is aggravated by the lack of AI-specific indicators tailored to public service contexts, particularly those that distinguish between readiness, adoption, and actual usage. As a result, important dimensions such as ethics, vision, economy, institutional capacity, or citizen trust remain insufficiently captured. Second, the use of nationally aggregated data limits the ability to assess disparities within countries, such as those based on income, gender, or geographic region, which are known to influence digital inclusion and public service access. Future research should expand the indicator base to include both structural and behavioural variables, ideally disaggregated by key demographic or regional dimensions. Longitudinal studies could better capture evolving AI readiness across member states.

7. Conclusion

A quantitative analysis of Eurostat data and the 2022 eGovernment Benchmark Report reveals an AI readiness gap among EU member states in e-government. Using factor and cluster analysis of nine proxy indicators, we identified two independent dimensions—Digital Skills and E-Government Engagement and Transparency, and E-Government Service Availability—highlighting disparities in digital public service preparedness. Our findings indicate that effective AI integration is closely associated with both institutional and citizen readiness, linking digital divide patterns to AI readiness levels. This suggests that policy strategies must address digital capacity and service accessibility simultaneously. Our work offers a comparative, data-driven assessment of a largely unexplored issue in public sector digital transformation.

CRedit authorship contribution statement

Eduardo Amaral: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis. **Mijail Naranjo-Zolotov:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Fernando Bação:** Writing – review & editing, Validation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

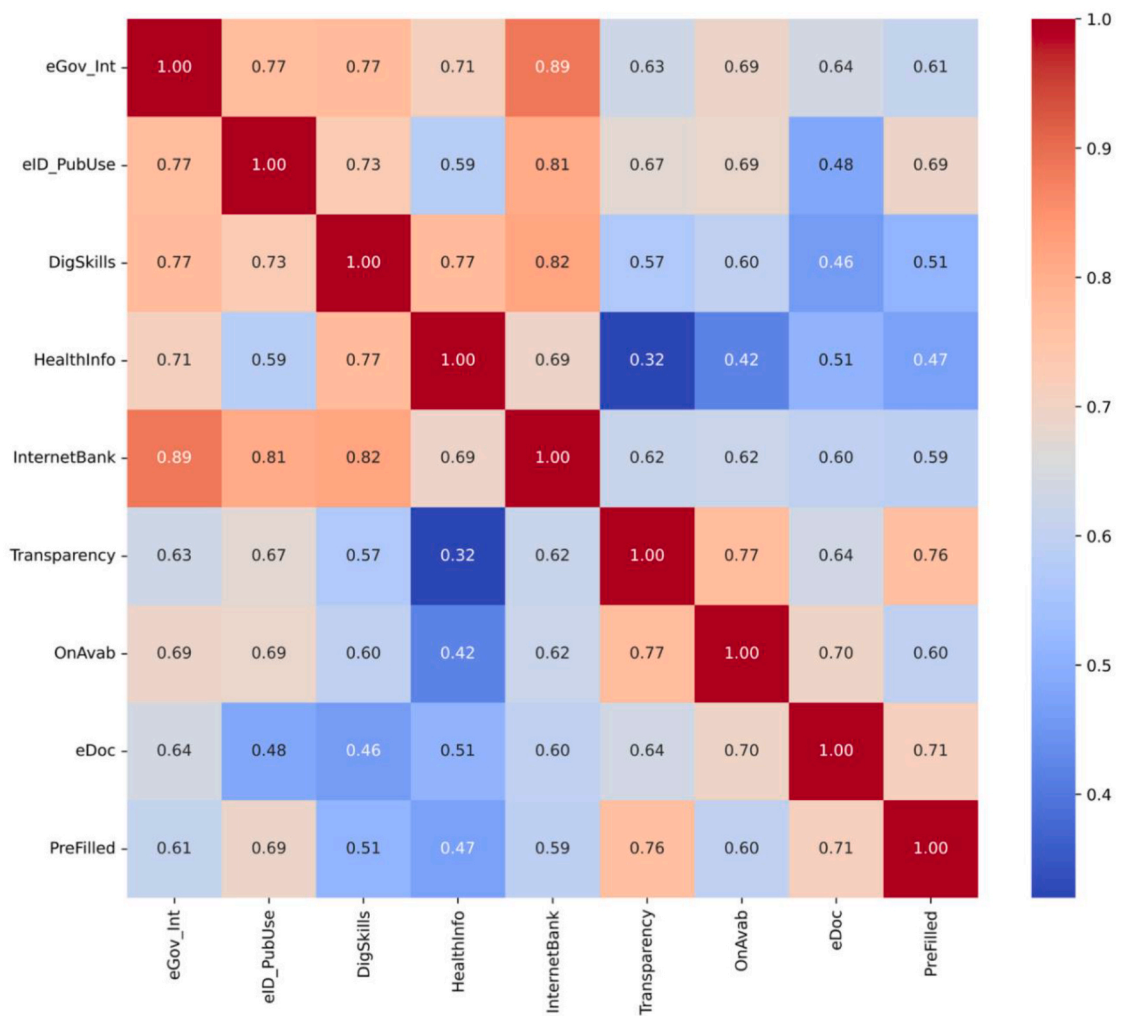
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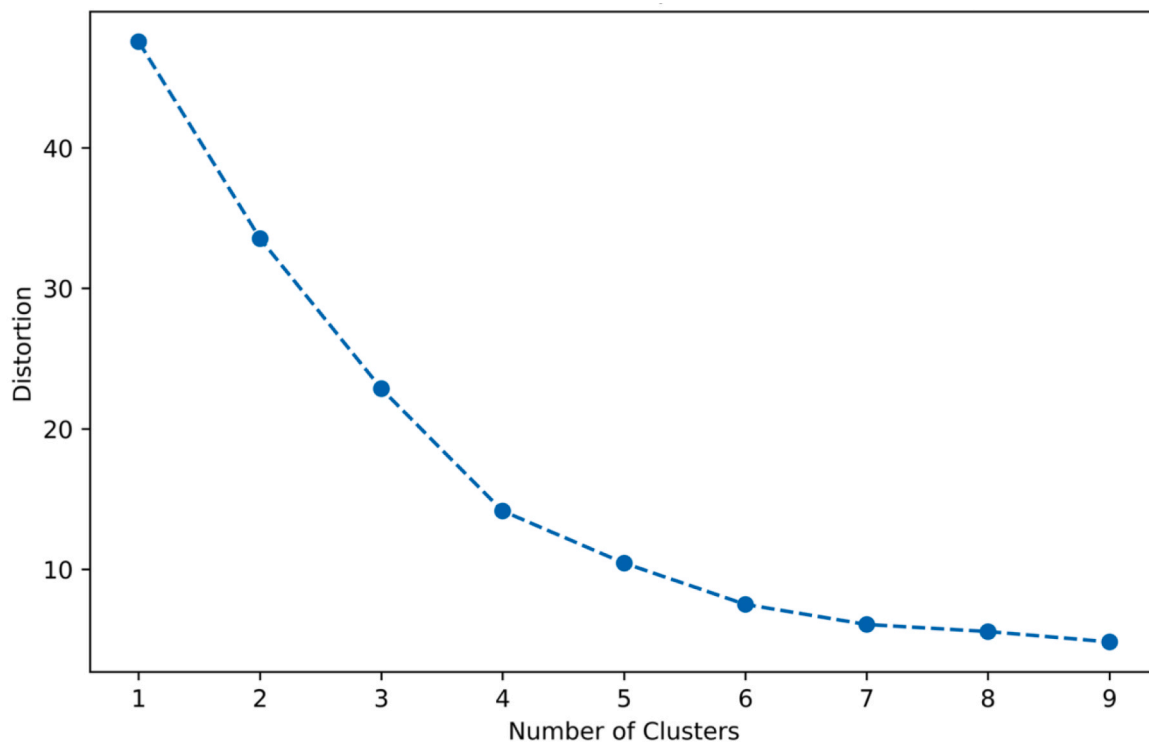
Appendix A. – Dataset

Country	Code	eGov_Int	eID_PubUse	DigSkills	HealthInfo	InternetBank	Transparency	OnAvab	eDoc	PreFilled
Austria	AT	59,54	37,09	32,04	62,82	73,13	71,07	91,4	87,9	71,20
Belgium	BE	70,51	59,10	28,26	52,58	79,51	65,51	90,5	84,3	77,16
Bulgaria	BG	19,43	5,36	7,73	39,09	22,44	51,22	80,5	63	63,75
Croatia	HR	51,97	36,70	25,00	59,00	57,96	52,44	91,3	66,8	38,33
Cyprus	CY	58,43	0,72	24,96	72,88	63,94	31,87	70,5	76,2	48,96
Czechia	CZ	56,01	25,21	35,48	62,44	77,09	57,31	86,7	56,5	41,94
Denmark	DK	91,51	83,94	39,37	70,81	94,35	78,02	99,6	96	87,30
Estonia	EE	78,39	82,76	34,84	59,48	83,36	86,73	95,7	95,5	87,50
Finland	FI	91,13	85,94	53,63	80,50	94,68	71,54	98,7	88,8	89,81
France	FR	65,06	41,82	30,62	50,26	67,86	64,90	92,1	89,7	47,31
Germany	DE	32,62	6,85	19,79	36,56	48,58	49,22	90,2	74,4	43,31
Greece	GR	59,26	60,33	20,02	56,60	49,78	52,44	91,3	66,1	54,38
Hungary	HU	70,34	28,81	28,13	68,10	61,04	56,60	94,8	92,1	60,00
Ireland	IE	66,64	64,86	43,82	50,32	82,87	70,76	90,3	66,5	61,30
Italy	IT	39,3	39,35	22,21	52,23	48,35	49,20	90,4	65,6	47,11
Latvia	LV	60,78	57,05	16,55	42,61	82,45	71,32	92,6	88,4	76,27
Lithuania	LT	63,77	60,44	25,90	61,89	74,82	77,65	91,7	92,5	93,41
Luxembourg	LU	78,19	44,29	27,86	46,35	69,96	89,65	95,5	72,8	71,85
Malta	MT	67,21	47,45	36,98	65,76	66,32	98,16	100	98,4	88,41
Netherlands	NL	82,15	94,99	54,53	78,01	90,72	81,32	94,9	85,4	94,01
Poland	PL	39,34	36,50	20,05	52,02	55,55	56,83	85,6	80,1	78,30
Portugal	PT	59,44	28,04	29,93	49,46	57,45	70,85	96,6	97,1	81,48
Romania	RO	14	1,58	8,97	28,92	19,19	43,82	70,5	38,8	40,74
Slovakia	SK	57,31	8,11	21,70	42,97	48,08	46,05	86,2	67,9	55,86
Slovenia	SI	62,81	21,80	18,88	50,22	56,86	64,23	92	80,9	72,04
Spain	ES	56,25	50,28	38,65	64,85	69,60	72,68	97,5	87	82,79
Sweden	SE	80,87	82,57	36,51	66,67	83,50	66,33	95,1	76,1	86,30
Mean		60.45	44.15	28.98	56.42	65.91	64.73	90.82	79.07	68.18
Std. Deviation		18.99	27.54	11.42	12.69	19.13	15.35	7.35	14.36	18.19
Minimum		14.00	0.72	7.73	28.92	19.19	31.87	70.50	38.80	38.33
Maximum		91.51	94.99	54.53	80.50	94.68	98.16	100.00	98.40	94.01

Appendix B. - Correlation matrix



Appendix C. – Elbow method



Data availability

Data is available in [Appendix A](#)

References

- Agency for Digital Government. (2019). *The Danish National Strategy for Artificial Intelligence*. <https://en.digst.dk/strategy/the-danish-national-strategy-for-artificial-intelligence/>.
- Al-Ansi, A.M., Garad, A., Jaboo, M., Al-Ansi, A., 2024. Elevating e-government: unleashing the power of AI and IoT for enhanced public services. *Heliyon* 10 (23), e40591. <https://doi.org/10.1016/j.heliyon.2024.e40591>.
- Ali, W., Khan, A.Z., 2025. Factors influencing readiness for artificial intelligence: a systematic literature review. *Data Sci. Manage.* 8 (2), 224–236. <https://doi.org/10.1016/j.dsm.2024.09.005>.
- Alvarez-Galvez, J., Salinas-Perez, J.A., Montagni, I., Salvador-Carulla, L., 2020. The persistence of digital divides in the use of health information: a comparative study in 28 European countries. *Int. J. Public Health* 65 (3), 325–333. <https://doi.org/10.1007/s00038-020-01363-w>.
- Andrade, N.N.G.D., 2012. Regulating electronic identity in the European Union: An analysis of the Lisbon Treaty's competences and legal basis for eID. *Comput. Law Sec. Rev.* 28 (2), 153–162. <https://doi.org/10.1016/j.clsr.2012.01.012>.
- Androutsopoulou, A., Karacapilidis, N., Loukis, E., Charalabidis, Y., 2019. Transforming the communication between citizens and government through AI-guided chatbots. *Gov. Inf. Q.* 36 (2), 358–367. <https://doi.org/10.1016/j.giq.2018.10.001>.
- Aoki, N., 2020. An experimental study of public trust in AI chatbots in the public sector. *Gov. Inf. Q.* 37 (4), 101490. <https://doi.org/10.1016/j.giq.2020.101490>.
- Aoki, N., Tatsumi, T., Naruse, G., Maeda, K., 2024. Explainable AI for government: Does the type of explanation matter to the accuracy, fairness, and trustworthiness of an algorithmic decision as perceived by those who are affected? *Gov. Inf. Q.* 41 (4), 101965. <https://doi.org/10.1016/j.giq.2024.101965>.
- Bailey, D.E., Barley, S.R., 2020. Beyond design and use: How scholars should study intelligent technologies. *Inf. Organ.* 30 (2), 100286. <https://doi.org/10.1016/j.infoandorg.2019.100286>.
- Barry, A., 2020. The Material Politics of Infrastructure. In: Maasen, S., Dickel, S., Schneider, C. (Eds.), *TechnoScienceSociety: Technological Reconfigurations of Science and Society*. Springer International Publishing, pp. 91–109. https://doi.org/10.1007/978-3-030-43965-1_6.
- Bélanger, F., Carter, L., 2009. The impact of the digital divide on e-government use. *Commun. ACM* 52 (4), 132–135. <https://doi.org/10.1145/1498765.1498801>.
- Bowker, G.C., Baker, K., Millerand, F., Ribes, D., 2009. Toward Information Infrastructure studies: ways of knowing in a networked environment. In: Hunsinger, J., Klastrop, L., Allen, M. (Eds.), *International Handbook of Internet Research*. Springer, Netherlands, pp. 97–117. https://doi.org/10.1007/978-1-4020-9789-8_5.
- Carter, L., Liu, D., Cantrell, C., 2020. Exploring the intersection of the digital divide and artificial intelligence: a hermeneutic literature review. *AIS Trans. Hum. Comput. Interact.* 12 (4), 253–275. <https://doi.org/10.17705/1thci.00138>.
- Cruz-Jesus, F., Oliveira, T., Bacao, F., 2012. Digital divide across the European Union. *Inf. Manage.* 49 (6), 278–291. <https://doi.org/10.1016/j.im.2012.09.003>.
- Cruz-Jesus, F., Vicente, M.R., Bacao, F., Oliveira, T., 2016. The education-related digital divide: an analysis for the EU-28. *Comput. Hum. Behav.* 56, 72–82. <https://doi.org/10.1016/j.chb.2015.11.027>.

- Ebbers, W.E., Jansen, M.G.M., Van Deursen, A.J.A.M., 2016. Impact of the digital divide on e-government: expanding from channel choice to channel usage. *Gov. Inf. Q.* 33 (4), 685–692. <https://doi.org/10.1016/j.giq.2016.08.007>.
- European Commission. (2010). *A Digital Agenda for Europe*. European Commission. <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0245:FIN:EN:PDF>.
- European Commission. (2023). *eGovernment Benchmark 2022 | Shaping Europe's digital future*. <https://digital-strategy.ec.europa.eu/en/library/egovernment-benchmark-2022>.
- European Commission. (2024). *The Digital Economy and Society Index (DESI) | Shaping Europe's digital future*. Digital Strategy. <https://digital-strategy.ec.europa.eu/en/policies/desi>.
- European Commission. Joint Research Centre. (2020). *AI Watch, artificial intelligence in public services: Overview of the use and impact of AI in public services in the EU*. Publications Office. <https://data.europa.eu/doi/10.2760/039619>.
- Eurostat. (2022). *Eurostat*. <https://ec.europa.eu/eurostat>.
- EY & Microsoft. (2020). *Artificial Intelligence in the Public Sector: European Outlook for 2020 and Beyond*. Microsoft. <https://info.microsoft.com/rs/157-GQE-382/images/EN-CNTNT-eBook-artificial-SRGCM3835.pdf>.
- Fatima, S., Desouza, K.C., Dawson, G.S., 2020. National strategic artificial intelligence plans: a multi-dimensional analysis. *Econ. Anal. Policy* 67, 178–194. <https://doi.org/10.1016/j.eap.2020.07.008>.
- Ferreira, D., Vale, M., Miguel Carmo, R., Encalada-Abarca, L., Marcolin, C., 2021. The three levels of the urban digital divide: Bridging issues of coverage, usage and its outcomes in VGI platforms. *Geoforum* 124, 195–206. <https://doi.org/10.1016/j.geoforum.2021.05.002>.
- Ferro, E., Helbig, N.C., Gil-Garcia, J.R., 2011. The role of IT literacy in defining digital divide policy needs. *Gov. Inf. Q.* 28 (1), 3–10. <https://doi.org/10.1016/j.giq.2010.05.007>.
- Foffano, F., Scantamburlo, T., Cortés, A., 2023. Investing in AI for social good: an analysis of European national strategies. *AI & Soc.* 38 (2), 479–500. <https://doi.org/10.1007/s00146-022-01445-8>.
- Gil-García, J.R., Martínez-Moyano, I.J., 2007. Understanding the evolution of e-government: the influence of systems of rules on public sector dynamics. *Gov. Inf. Q.* 24 (2), 266–290. <https://doi.org/10.1016/j.giq.2006.04.005>.
- Grishchenko, N., 2024. Spatial-temporal evolution of digital skills in the EU countries. *Telematics Inform.* 94, 102185. <https://doi.org/10.1016/j.tele.2024.102185>.
- Hafeezallah, A., Al-Dhamari, A., Abu-Bakar, S.A.R., 2024. Motion segmentation using Ward's hierarchical agglomerative clustering for crowd disaster risk mitigation. *Int. J. Disaster Risk Reduct.* 102, 104262. <https://doi.org/10.1016/j.ijdr.2024.104262>.
- Hair, J. F., Babin, B. J., Anderson, R. E., & Black, W. C. (2019). *Multivariate data analysis* (Eighth edition). Cengage.
- Holmström, J., 2022. From AI to digital transformation: the AI readiness framework. *Bus. Horiz.* 65 (3), 329–339. <https://doi.org/10.1016/j.bushor.2021.03.006>.
- Janssen, M., Brous, P., Estevez, E., Barbosa, L.S., Janowski, T., 2020. Data governance: organizing data for trustworthy Artificial Intelligence. *Gov. Inf. Q.* 37 (3), 101493. <https://doi.org/10.1016/j.giq.2020.101493>.
- Janssen, M., Van Den Hoven, J., 2015. Big and Open linked data (BOLD) in government: a challenge to transparency and privacy? *Gov. Inf. Q.* 32 (4), 363–368. <https://doi.org/10.1016/j.giq.2015.11.007>.
- Jöhnk, J., Weißert, M., Wyrki, K., 2021. Ready or not, AI comes—an interview study of organizational AI readiness factors. *Bus. Inf. Syst. Eng.* 63 (1), 5–20. <https://doi.org/10.1007/s12599-020-00676-7>.
- Kaiser, H. F. (1974). An Index of Factorial Simplicity. *Psychometrika*, 39(1), 31–36. <https://doi.org/10.1007/BF02291575>.
- Kaltoft, M.K., Dowie, J., Turner, R., Nielsen, J.B., Salkeld, G., Cunich, M., 2013. Addressing the disconnect between public health science and personalised health care: The potential role of cluster analysis in combination with multi-criteria decision analysis. *Lancet* 382, S52. [https://doi.org/10.1016/S0140-6736\(13\)62477-0](https://doi.org/10.1016/S0140-6736(13)62477-0).
- Koh, C.E., Prybutok, V.R., Zhang, X., 2008. Measuring e-government readiness. *Inf. Manage.* 45 (8), 540–546. <https://doi.org/10.1016/j.im.2008.08.005>.
- Koivisto, J., Keski-Kuha, T., Lähteenmäki, J., Sourkatti, H., Kettunen, P., Vesala, J., 2023. Anticipating multisectoral use of services with the support of AI. *Int. J. Integr. Care* 23 (S1), 271. <https://doi.org/10.5334/ijic.ICIC23430>.
- Kulal, A., Rahiman, H.U., Suvarna, H., Abhishek, N., Dinesh, S., 2024. Enhancing public service delivery efficiency: exploring the impact of AI. *J. Open Innovat. Technol. Market Complexity* 10 (3), 100329. <https://doi.org/10.1016/j.joitmc.2024.100329>.
- Kuziemski, M., Misuraca, G., 2020. AI governance in the public sector: three tales from the frontiers of automated decision-making in democratic settings. *Telecommun. Policy* 44 (6), 101976. <https://doi.org/10.1016/j.telpol.2020.101976>.
- Larsson, K.K., 2021. Digitization or equality: when government automation covers some, but not all citizens. *Gov. Inf. Q.* 38 (1), 101547. <https://doi.org/10.1016/j.giq.2020.101547>.
- Laux, J., Wachter, S., Mittelstadt, B., 2024. Trustworthy artificial intelligence and the European Union AI act: on the conflation of trustworthiness and acceptability of risk. *Regul. Governance* 18 (1), 3–32. <https://doi.org/10.1111/rego.12512>.
- Lepeniotti, K., Bousdekis, A., Apostolou, D., Mentzas, G., 2021. Human-augmented prescriptive analytics with interactive multi-objective reinforcement learning. *IEEE Access* 9, 100677–100693. <https://doi.org/10.1109/ACCESS.2021.3096662>.
- Li, M., 2011. Online government advisory service innovation through Intelligent support systems. *Inf. Manage.* 48 (1), 27–36. <https://doi.org/10.1016/j.im.2010.12.002>.
- Lin, J., Carter, L., Liu, D., 2021. Privacy concerns and digital government: exploring citizen willingness to adopt the COVIDSafe app. *Eur. J. Inf. Syst.* 30 (4), 389–402. <https://doi.org/10.1080/0960085X.2021.1920857>.
- Lnenicka, M., Luterek, M., Majo, L.T., 2024. Analysis of e-government and digital society indicators over the years: a comparative study of the EU member states. *Digital Policy Regul. Governance* 26 (5), 560–582. <https://doi.org/10.1108/DPRG-07-2023-0103>.
- Lnenicka, M., Nikiforova, A., 2021. Transparency-by-design: what is the role of open data portals? *Telematics Inform.* 61, 101605. <https://doi.org/10.1016/j.tele.2021.101605>.
- Lokuge, S., Sedera, D., Grover, V., Dongming, X., 2019. Organizational readiness for digital innovation: development and empirical calibration of a construct. *Inf. Manage.* 56 (3), 445–461. <https://doi.org/10.1016/j.im.2018.09.001>.
- Madan, R., Ashok, M., 2023. AI adoption and diffusion in public administration: A systematic literature review and future research agenda. *Gov. Inf. Q.* 40 (1), 101774. <https://doi.org/10.1016/j.giq.2022.101774>.
- Madariaga, L., Nussbaum, M., Marañón, F., Alarcón, C., Naranjo, M.A., 2019. User experience of government documents: a framework for informing design decisions. *Gov. Inf. Q.* 36 (2), 179–195. <https://doi.org/10.1016/j.giq.2018.12.005>.
- Mathews, R., Janssen, M., 2020. A systematic literature study to unravel transparency enabled by open government data: the window theory. *Public Perform. Manag. Rev.* 43 (3), 503–534. <https://doi.org/10.1080/15309576.2019.1691025>.
- Medaglia, R., Gil-Garcia, J.R., Pardo, T.A., 2023. Artificial intelligence in government: taking stock and moving forward. *Soc. Sci. Comput. Rev.* 41 (1), 123–140. <https://doi.org/10.1177/08944393211034087>.
- Mergel, I., Edelman, N., Haug, N., 2019. Defining digital transformation: Results from expert interviews. *Gov. Inf. Q.* 36 (4), 101385. <https://doi.org/10.1016/j.giq.2019.06.002>.
- Merkel, S., Hess, M., 2020. The use of internet-based health and care services by elderly people in Europe and the importance of the country context: multilevel study. *JMIR Aging* 3 (1), e15491. <https://doi.org/10.2196/15491>.
- Ministerstwo Cyfryzacji. (2024). *Strategia cyfryzacji państwa – projekt do konsultacji społecznych*. <https://www.gov.pl/web/cyfryzacja/strategia-cyfryzacji-panstwa-wyniki-konsultacji-spoecznych>.
- Ministry of Public Administration, Republic of Slovenia. (2021). *National Programme to Promote the Development and Use of Artificial Intelligence in the Republic of Slovenia by 2025*. https://www.gov.si/assets/ministrstva/MDP/National_Programme_for_AI_2025.pdf.
- Mitrović, Đ., 2020. Measuring the efficiency of digital convergence. *Econ. Lett.* 188, 108982. <https://doi.org/10.1016/j.econlet.2020.108982>.
- Mökander, J., Schroeder, R., 2024. Artificial intelligence, rationalization, and the limits of control in the public sector: the case of tax policy optimization. *Soc. Sci. Comput. Rev.* 42 (6), 1359–1378. <https://doi.org/10.1177/08944393241235175>.

- Molnár-Gábor, F., 2018. Germany: a fair balance between scientific freedom and data subjects' rights? *Hum. Genet.* 137 (8), 619–626. <https://doi.org/10.1007/s00439-018-1912-1>.
- Organisation for Economic Co-operation and Development (OECD). (2001). *Understanding the Digital Divide* (OECD Digital Economy Papers No. 49; OECD Digital Economy Papers, Vol. 49). <https://doi.org/10.1787/236405667766>.
- Oxford Insights. (2024). *2024 Government AI Readiness Index*. <https://oxfordinsights.com/ai-readiness/ai-readiness-index/>.
- Pang, M.-S., Lee, G., DeLone, W.H., 2014. IT resources, organizational capabilities, and value creation in public-sector organizations: a public-value management perspective. *J. Inf. Technol.* 29 (3), 187–205. <https://doi.org/10.1057/jit.2014.2>.
- Papadimitriou, D., Baltag, D., Surubaru, N.-C., 2017. Assessing the performance of the European Union in Central and Eastern Europe and in its neighbourhood. *East Eur. Politics* 33 (1), 1–16. <https://doi.org/10.1080/21599165.2017.1279608>.
- Paroški, M., 2025. Towards harmonization of EU and UN methodologies for the assessment of eGovernment. *Telematics Inform.* 96, 102199. <https://doi.org/10.1016/j.tele.2024.102199>.
- Profiroiu, C.M., Negoită, C.I., Costea, A.V., 2024. Digitalization of public administration in EU member states in times of crisis: the contributions of the national recovery and resilience plans. *Int. Rev. Adm. Sci.* 90 (2), 336–352. <https://doi.org/10.1177/00208523231177554>.
- Rowland, N.J., Passoth, J.-H., 2015. Infrastructure and the state in science and technology studies. *Soc. Stud. Sci.* 45 (1), 137–145. <https://doi.org/10.1177/0306312714537566>.
- Scheerder, A., Van Deursen, A., Van Dijk, J., 2017. Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. *Telematics Inform.* 34 (8), 1607–1624. <https://doi.org/10.1016/j.tele.2017.07.007>.
- Schneider, D., Klumpe, J., Adam, M., Benlian, A., 2020. Nudging users into digital service solutions. *Electron. Mark.* 30 (4), 863–881. <https://doi.org/10.1007/s12525-019-00373-8>.
- Scholta, H., Balta, D., Räckers, M., Becker, J., Krcmar, H., 2020. Standardization of Forms in Governments: a meta-model for a reference form modeling language. *Bus. Inf. Syst. Eng.* 62 (6), 535–560. <https://doi.org/10.1007/s12599-019-00623-1>.
- Scholta, H., Mertens, W., Kowalkiewicz, M., Becker, J., 2019. From one-stop shop to no-stop shop: an e-government stage model. *Gov. Inf. Q.* 36 (1), 11–26. <https://doi.org/10.1016/j.giq.2018.11.010>.
- Sheoran, S., Vij, S., 2022. A Review of e-government assessment frameworks: e-readiness, adoption, citizen engagement and quality : E-readiness, adoption, citizen engagement and quality. *JeDEM - eJournal of eDemocracy and Open Government* 14 (2), 197–213. <https://doi.org/10.29379/jedem.v14i2.717>.
- Socol, A., Iuga, I.C., 2024. Addressing brain drain and strengthening governance for advancing government readiness in artificial intelligence (AI). *Kybernetes* 53 (13), 47–71. <https://doi.org/10.1108/K-03-2024-0629>.
- Straub, V.J., Morgan, D., Bright, J., Margetts, H., 2023. Artificial intelligence in government: concepts, standards, and a unified framework. *Gov. Inf. Q.* 40 (4), 101881. <https://doi.org/10.1016/j.giq.2023.101881>.
- Sun, T.Q., Medaglia, R., 2019. Mapping the challenges of Artificial Intelligence in the public sector: evidence from public healthcare. *Gov. Inf. Q.* 36 (2), 368–383. <https://doi.org/10.1016/j.giq.2018.09.008>.
- Surubaru, N.-C., 2017. Administrative capacity or quality of political governance? EU Cohesion Policy in the new Europe, 2007–13. *Reg. Stud.* 51 (6), 844–856. <https://doi.org/10.1080/00343404.2016.1246798>.
- Švarc, J., Lažnjak, J., Dabić, M., 2021. The role of national intellectual capital in the digital transformation of EU countries. Another digital divide? *J. Intellect. Cap.* 22 (4), 768–791. <https://doi.org/10.1108/JIC-02-2020-0024>.
- Takieddine, S., Sun, J., 2015. Internet banking diffusion: a country-level analysis. *Electron. Commer. Res. Appl.* 14 (5), 361–371. <https://doi.org/10.1016/j.elerap.2015.06.001>.
- Tangi, L., Rodriguez Müller, A.P., Janssen, M., 2025. AI-augmented government transformation: Organisational transformation and the sociotechnical implications of artificial intelligence in public administrations. *Gov. Inf. Q.* 42 (3), 102055. <https://doi.org/10.1016/j.giq.2025.102055>.
- Tangi, L., Van Noordt, C., & Rodriguez Müller, A. P. (2023). The challenges of AI implementation in the public sector. An in-depth case studies analysis. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 414–422. <https://doi.org/10.1145/3598469.3598516>.
- Tavares, A.I., 2020. Self-assessed health among older people in Europe and internet use. *Int. J. Med. Inf.* 141, 104240. <https://doi.org/10.1016/j.ijmedinf.2020.104240>.
- Trajkovski, G., 2024. Bridging the public administration-AI divide: A skills perspective. *Public Adm. Dev.* 44 (5), 412–426. <https://doi.org/10.1002/pad.2061>.
- Troitino, D.R., Mazur, V., Kerikmäe, T., 2024. E-governance and integration in the European union. *Internet Things* 27, 101321. <https://doi.org/10.1016/j.iot.2024.101321>.
- Tutak, M., Brodny, J., 2024. Technological progress in central and eastern Europe: Digitalization and business innovation leaders and outsiders. *J. Open Innovat. Technol. Market Complex.* 10 (4), 100404. <https://doi.org/10.1016/j.oiotmc.2024.100404>.
- Twizeyimana, J.D., Andersson, A., 2019. The public value of E-government – a literature review. *Gov. Inf. Q.* 36 (2), 167–178. <https://doi.org/10.1016/j.giq.2019.01.001>.
- UNESCO. (2023). Readiness assessment methodology. A tool of the Recommendation on the Ethics of Artificial Intelligence. UNESCO. <https://doi.org/10.54678/YHAA4429>.
- United Nations. (2022). *E-Government survey 2022: The future of digital government*. <https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2022>.
- Uren, V., Edwards, J.S., 2023. Technology readiness and the organizational journey towards AI adoption: an empirical study. *Int. J. Inf. Manag.* 68, 102588. <https://doi.org/10.1016/j.ijinfomgt.2022.102588>.
- van Deursen, A. J. A. M., & Helsper, E. J. (2015). The Third-Level Digital Divide: Who Benefits Most from Being Online? In *Communication and Information Technologies Annual* (Vol. 10, p. 0). Emerald Group Publishing Limited. <https://doi.org/10.1108/S2050-206020150000010002>.
- Van Dijk, J., Jacobs, B., 2020. Electronic identity services as sociotechnical and political-economic constructs. *New Media Soc.* 22 (5), 896–914. <https://doi.org/10.1177/1461444819872537>.
- Van Kolschooten, H., 2023. The AI cycle of health inequity and digital ageism: Mitigating biases through the EU regulatory framework on medical devices. *J. Law Biosci.* 10 (2), lsad031. <https://doi.org/10.1093/jlb/lsad031>.
- Van Kolschooten, H., Van Oirschot, J., 2024. The EU artificial intelligence act (2024): implications for healthcare. *Health Policy* 149, 105152. <https://doi.org/10.1016/j.healthpol.2024.105152>.
- Van Noordt, C., Misuraca, G., 2022a. Artificial intelligence for the public sector: Results of landscaping the use of AI in government across the European Union. *Gov. Inf. Q.* 39 (3), 101714. <https://doi.org/10.1016/j.giq.2022.101714>.
- Van Noordt, C., Misuraca, G., 2022b. Exploratory insights on artificial intelligence for government in Europe. *Soc. Sci. Comput. Rev.* 40 (2), 426–444. <https://doi.org/10.1177/0894439320980449>.
- Wang, C., Boerman, S. C., Kroon, A. C., Möller, J., & H De Vreese, C. (2024). The artificial intelligence divide: Who is the most vulnerable? *New Media & Society*, 14614448241232345. <https://doi.org/10.1177/14614448241232345>.
- Wang, S., Xiao, Y., Liang, Z., 2024b. Exploring cross-national divide in government adoption of artificial intelligence: Insights from explainable artificial intelligence techniques. *Telematics Inform.* 90, 102134. <https://doi.org/10.1016/j.tele.2024.102134>.
- Webster, J., Watson, R.T., 2002. Analyzing the past to prepare for the future: writing a literature review. *MIS Quarterly* 26 (2).
- Wirtz, B.W., Müller, W.M., 2019. An integrated artificial intelligence framework for public management. *Public Manag. Rev.* 21 (7), 1076–1100. <https://doi.org/10.1080/14719037.2018.1549268>.
- Wirtz, B.W., Weyerer, J.C., Geyer, C., 2019. Artificial intelligence and the public sector—applications and challenges. *Int. J. Public Adm.* 42 (7), 596–615. <https://doi.org/10.1080/01900692.2018.1498103>.
- Wirtz, B.W., Weyerer, J.C., Sturm, B.J., 2020. The dark sides of artificial intelligence: an integrated AI governance framework for public administration. *Int. J. Public Adm.* 43 (9), 818–829. <https://doi.org/10.1080/01900692.2020.1749851>.

- Yera, A., Arbelaitz, O., Jauregui, O., Muguerza, J., 2020. Characterization of e-government adoption in Europe. *PLoS One* 15 (4), e0231585. <https://doi.org/10.1371/journal.pone.0231585>.
- Zídková, H., Arltová, M., Josková, K., 2024. Does the level of e-government affect value-added tax collection? A study conducted among the European Union Member States. *Policy Internet* 16 (3), 567–587. <https://doi.org/10.1002/poi3.389>.
- Zuiderwijk, A., Chen, Y.-C., Salem, F., 2021. Implications of the use of artificial intelligence in public governance: a systematic literature review and a research agenda. *Gov. Inf. Q.* 38 (3), 101577. <https://doi.org/10.1016/j.giq.2021.101577>.