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Digital accountability through e-participation: the moderating role of the digital divide

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IMPACT

The authors show that equitable access to digital technologies enhances the effectiveness of e-participation, enabling citizens to monitor, evaluate, and influence public sector decision-making more meaningfully. The findings presented in this article have important implications for policy-makers—infrastructure expansion alone cannot achieve digital accountability. Instead, digital inclusion and civic engagement must be addressed through investments in broadband access, digital literacy, and participatory platforms. Bridging the digital divide ensures that accountability mechanisms are accessible to all, thus promoting transparency, responsiveness, and trust in government. By connecting digital transformation to participatory governance, this article supports efforts toward sustainable and inclusive public administration, offering guidance for building citizen-centreed digital governance frameworks.

ABSTRACT

The authors investigated the relationship between e-participation and digital accountability, with a particular focus on how the digital divide moderated this relationship across the EU 27 between 2018 and 2022. Using panel data Feasible Generalized Least Squares (FGLS) estimation, the authors examined how broadband access disparities influence the effectiveness of citizen engagement in fostering accountability. The study contributes to the literature by offering a conceptual and empirical framework that treats the digital divide as a background condition and a dynamic factor shaping participatory outcomes. Operationalizing digital accountability through distinct dimensions of transparency also advances accountability measurement in the digital era. The findings underscore that expanding e-government services alone is insufficient; digital inclusion and civic engagement must be pursued together. The study highlights the importance of integrated strategies that combine infrastructure investment with efforts to ensure accessible, inclusive, and effective public participation. While focused on the EU, the framework holds relevance for other governance contexts addressing digital inequality.

KEYWORDS

Citizen-centreed governance; digital accountability; digital divide; digital governance; digital inclusion; e-government services; e-participation; panel data

Introduction

Public sector organizations and services have experienced rapid digitalization over the past decade, driven by the widespread adoption of information and communication technologies (ICTs) (Agostino et al., 2022a). This transition to digital governance (Dunleavy et al., 2006) has transformed governmental practices and introduced new accountability mechanisms—such as e-government portals, open data platforms, citizen feedback tools, and digital service interfaces—that facilitate transparency, responsiveness, and public oversight (Agostino et al., 2022b), thus paving the way for the engagement of citizens in decision-making (Karkin & Cezar, 2024). As a result, Steccolini (2025, p. 1) argues for a transformation in the monological view of public accountability in favour of a dialogical accounting perspective, where the plurality of 'accountees' and their abilities to hold the public sector accountable needs to be considered given the changes in global context 'how citizens and other actors hold public sector entities accountable, often empowered by technological advancements'. These mechanisms can enhance digital accountability, enable citizen engagement, and foster transparency (Iuliano et al., 2024). However, the realization of digital accountability depends heavily on e-participation, which remains constrained by persistent digital inequalities.

These inequalities, referred to as the 'digital divide', represent disparities in access to ICTs—such as broadband connectivity, the availability of digital devices, and levels of digital literacy (Zhang et al., 2025). The digital divide excludes vulnerable groups from participating in digital governance processes and creates barriers to effectively engaging with digital platforms (Sparks, 2013). As a result, when large segments of the population cannot access e-government portals, open data services, or citizen feedback systems, their capacity to engage with, monitor, and hold public institutions accountable is significantly constrained. This, in turn, undermines the accountability potential of digital mechanisms and reinforces structural inequities in governance outcomes. Previous studies have largely taken for granted that digital services inherently lead to improved digital accountability or, conversely, argued that digitalization exacerbates accountability challenges (i.e. Polzer & Öner, 2025; Al-Shbail & Aman, 2018). However, these perspectives often overlook the critical role of e-participation, which offers a more meaningful lens for understanding how citizens interact with and benefit from digital governance than merely

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examining the availability of online services provided by governments (Karkin & Cezar, 2024; Sharma et al., 2024).

For e-participation to be effective, citizens not only access but also actively engage in shaping public decisions through digital platforms; therefore, governments must go beyond simply offering online services. Citizens also need equitable access to these services and the necessary digital infrastructure, skills, and literacy to utilize them (Sparks, 2013). This is where the digital divide becomes a crucial factor. Digital accountability—the capacity of institutions to uphold transparency, responsiveness, and responsibility through digital means—relies heavily on citizen engagement (Agostino et al., 2022b). E-participation is the primary mechanism through which citizens interact with digital governance tools, enabling them to access information, provide feedback, and influence decision-making processes (Wirtz et al., 2018). Without active e-participation, digital services risk becoming one-way communication channels rather than tools for democratic oversight and responsiveness (Karkin & Cezar, 2024). Despite this interdependence, only a limited number of studies have examined how disparities in digital access affect the strength of the relationship between e-participation and digital accountability (i.e. Mao et al., 2024). By integrating the digital divide concept into this framework, this study addresses a significant gap in the literature, offering new insights into how unequal access to digital resources can affect the ability of e-participation to enhance accountability outcomes.

Building on this foundation, this article focuses on the impact of e-participation on digital accountability and investigates how the digital divide moderates this relationship. Will higher levels of e-participation ensure digital accountability in contexts where digital inequalities persist? Our research questions were:

What is the impact of e-participation on digital accountability?

Does the digital divide significantly moderate the relationship between e-participation and digital accountability?

By investigating the relationship between e-participation and digital accountability in the EU 27, we make three contributions to the literature:

- First, we advance theoretical understanding by exploring how the digital divide shapes the conditions under which e-participation can foster accountable and transparent governance.
- Second, we contribute conceptually by proposing a framework that treats the digital divide not merely as a contextual factor but as a moderating influence that dynamically interacts with citizen engagement.
- Third, we offer a methodological contribution by applying a panel data approach using feasible generalized least squares (FGLS) estimation.

We incorporated interaction effects and control variables to disentangle the individual and combined impacts of e-participation and digital inequality. The analysis draws on harmonized data from major international organizations—the European Commission (EC), United Nations, Eurostat, and the World Bank—covering the EU 27 between 2018 and 2022.

Conceptual framework

Digital accountability, e-participation, and the digital divide

Accountability has been conceptualized in multiple forms and shapes (Sinclair, 1995), including public accountability (answerability to the public for decisions), parliamentary accountability (responsibility to legislative bodies), political accountability (elected representatives being answerable to citizens), and managerial accountability (evaluating performance based on operational outcomes) (Parker & Favotto, 2025). In this article, we focus on one distinct form: digital accountability (Agostino et al., 2022a).

The ongoing digital transformation in the public sector has altered how organizations are governed (Dunleavy et al., 2006). Digitalization has reshaped the way organizations coordinate and collaborate. It has added new responsibilities to public sector organizations, such as securing public and citizen information, and elevated citizens' expectations of public sector organizations, such as transparency in the handling of personal data, utilization of digital infrastructure, and access to online services and internet usage (Agostino et al., 2022b). Digitalization necessitates revisiting and reconsidering accountability relationships and mechanisms, and digital accountability stands as a distinct form of accountability among the other accountability forms (Agostino et al., 2022a; Sinclair, 1995).

One of the most important effects of digital accountability is heightened pressure for transparency from citizens and collaborating partners concerning the processing of personal and public data. As public sector activities become increasingly digitized and data-driven, governments are expected to be more transparent in their operations (Polzer & Öner, 2025; Agostino et al., 2022b). Citizens and other stakeholders are demanding access to the information generated and processed. This transparency expectation necessitates robust mechanisms to ensure the accurate and comprehensible presentation of the data, requiring finding a balance between openness and accountability (Agostino et al., 2022b). Furthermore, the challenge extends to sustaining meaningful citizen engagement and participation in influencing the generation and use of information. Since e-government relies heavily on data-driven insights, citizens must actively shape policies, provide feedback, and participate in decision-making to enhance public value creation (Karkin & Cezar, 2024). As such, several studies have critically analysed the democracy–accountability nexus, focusing on citizen engagement, authority, and control.

Amid growing concerns about the collection, storage, and use of vast amounts of personal data, different forms of accountability highlight that transparency depends on effective implementation and active public engagement (Pina et al., 2007). At the same time, scholars emphasize issues of data privacy and ethical data use (Agostino et al., 2022b), while others point to the empowering role of technology in maintaining accountability (Sharma et al., 2024). In the digital era, accountability is conceptualized as a mix of diverse practices, technologies, and theoretical frameworks, highlighting the indispensability of data analytics and digital record-keeping in ensuring accurate and timely reporting (Begkos et al., 2023). Adding on this, Otia and Bracci (2022) address the implications of rapid

technological developments on accountability mechanisms, such as auditing practices. Their insights reveal an urgent need for adaptive methodologies to maintain accountability and transparency in an increasingly digitized context.

Digital platforms can facilitate mechanisms for holding public officials accountable for their actions and decisions (Pina et al., 2007), such as online reporting systems, through which citizens can report misconduct and inefficiencies, prompting authorities to take corrective measures and uphold accountability standards (Begkos et al., 2023). Using first-generation panel estimation techniques to investigate the effect of e-government on accountability, Zou et al. (2023) found that e-government increased accountability. Amosun et al. (2021) found that e-government usage significantly improved citizens' perceptions of government transparency during the Covid 19 pandemic. A lack of transparency indicates that the state's inner workings are not readily visible or understandable to the public (Matheus et al., 2021). Online public services have been shown to facilitate accessible information sharing, empowering citizens, building trust, and promoting accountability, which are all vital for prioritizing citizen interests (Sharma et al., 2024).

Previous studies have often assumed that digital services inherently lead to increased digital accountability. However, this study questions whether this relationship is inherent and argues that the effect of digitized services on digital accountability depends significantly on how citizens use and benefit from these digitized services, namely, e-participation. In this context, e-participation is critical in understanding the connection between digital services and accountability.

E-participation and digital accountability

While there is no universally agreed-upon definition of 'e-participation' (electronic participation, online participation, or digital participation) in the relevant literature, numerous definitive elements have been identified. The concept is primarily characterized by various interactive dimensions, including virtual dialogue and stakeholder interactions (Viborg Andersen et al., 2007), the extension and transformation of participation in democratic and consultative societal processes (Sæbø et al., 2008), the inclusion of stakeholders in public decision-making (Wirtz et al., 2018), the transformation and extension of citizen participation in policy-making through ICTs and enabling citizens' active engagement in public matters via digital platforms and technologies (Shin et al., 2024). In this context, e-participation refers to using digital technologies to enable and enhance stakeholder engagement in public decision-making processes to enhance and make the delivery of public services better-fit stakeholders' needs and expectations. When evaluating the evolutionary path of the e-participation concept, we see that e-participation has e-democracy (political perspective) and e-government (administrative perspective) dimensions consisting of both demand and supply-side aspects (Cezar, 2024). In this context, e-participation initiatives have repercussions on digital accountability concerning political and administrative perspectives. Existing studies highlight its potential to amplify stakeholders' voices and strengthen government accountability through implementing ICTs (Mao et al., 2024; Sharma et al., 2024). While Mao et al. (2024) clearly assert that the potential of e-participation lies in improving stakeholder voice by speaking up and augmenting impact for the accountability of governments. They have found that growing e-participation tools and mechanisms have an impact on three consecutive stages of e-participation as e-information, e-consultation, and e-decision making. By empowering stakeholders, including citizens, e-participation positions them not just as end-users, but collaborators and partners in shaping services and policies related to government operations (Sharma et al., 2024) by embedding their input and insights regarding the design of public policies and the provision of public services. As Schmidt (2013) has firmly put it, accountability basically means the responsiveness of official actors 'to participatory input demands and can be held responsible for their output decisions' (p. 6). From this perspective, e-participation augments the inclination of governments to become more transparent and accountable as the presence of stakeholders is at stake. In this context, Randma-Liiv (2022) firmly argues that the development of e-participation platforms has the potential to break the routine by going beyond government business as usual. According to Randma-Liiv (2022), e-participation adds the involvement of cross-boundary collaboration to routine mechanisms that might imply 'that traditional mandatory, hierarchically oriented accountability gets supplemented by more voluntary horizontal and pluralistic accountability relations in order to cover the cross-cutting issues and activities transcending organizational boundaries' (p. 1041).

E-participation leverages various online platforms, tools, and channels to promote transparency, inclusivity, and accessibility in governance (Iuliano et al., 2024). As corruption remains a persistent issue across all governments, regardless of political systems or regime types, stakeholder involvement has been proposed as a potential solution (Zheng, 2016). In the digital era, transparency and accountability in governance are enhanced through mechanisms such as online voting, direct citizen participation, and citizen empowerment, as well as co-creation and co-production facilitated by ICTs. Studies in the relevant literature (Zheng, 2016) provide empirical evidence that citizen involvement through ICTs can enhance service delivery performance, increase government officials' responsibility, and improve government accountability and transparency. These improvements, in turn, reduce corruption and positively influence public perceptions. Focusing on a specific issue, budget transparency, Bisogno et al. (2022) argue that e-participation has a positive relationship with accountability, emphasizing the accountability dimension as crucial for facilitating greater citizen engagement. This positive link can be attributed to stakeholders' access to information, where ICTs play an indispensable role.

Recent research by Karkin and Cezar (2024) demonstrates that e-participation enhances public value by promoting transparency, fostering accountability, and reducing government corruption. Furthermore, it facilitates citizens' access to government information and services, empowering them to monitor governance activities and hold service providers accountable (Wirtz et al., 2018). The analysis conducted by Waheduzzaman and Khandaker (2022) reveals a significant relationship between e-

participation and both corruption perception and government effectiveness. However, they find that the relationship between e-participation, voice, and accountability is insignificant. They argue that the current form of e-participation may constrain its ability to amplify citizens' voices and ensure government accountability. Consequently, they advocate redesigning e-participation methods and tools to elevate citizens' voices better and strengthen accountability mechanisms. Randma-Liiv (2022) highlights the multiplicity of actors involved in e-participation processes as a factor that increases complexity. This is particularly relevant in e-participation and accountability, as collaboration among multiple actors can create ambiguity due to the emergence of partnerships and networks, directly impacting accountability. Due to its high importance considering democracy, transparency, and public value generation, our first hypothesis was:

H1: E-participation increases digital accountability.

Higher degrees of e-participation are expected to positively influence digital accountability by fostering transparency, amplifying marginalized voices, and creating channels for participatory decision-making (Karkin & Cezar, 2024). It should be noted that e-participation is not a novel concept or process; rather, it is an augmented type of offline public participation with a longer and wider background compared to online participation initiatives. The main nuance is the mediation of public participation as an augmented process through ICT means and tools. In other words, e-participation mediates the interaction between government and stakeholders as a technological enabler by deploying ICTs embedded in the broader governance process. Tai et al. (2020) find a strong association between online and offline participation, and e-participation can mobilize a broader range of stakeholders to engage in government business. Xu et al. (2022) found that online means provide stakeholders with more participation opportunities compared to offline participative means, particularly given the lack of political resources or existing disparities. However, it should be underlined that ubiquitous deployment of ICTs or higher levels of accessibility to ICTs might not reverse apathy that could impact both online and offline participation (Yetano & Royo, 2017). In this context, citizen awareness and literacy about the existence and utility of these digital services influence how effectively they engage with and leverage such tools to foster digital accountability. Nonetheless, there are some factors that impede the expected outputs or outcomes from e-participation, which are taken for granted as if they are the default. The digital divide, disparities in access to digital infrastructure, quality, and efficiency of online services, and digital literacy may be put forward in this context. These issues create significant barriers to equitable e-participation and, consequently, to achieving meaningful digital accountability.

The digital divide as a moderator between e-participation and digital accountability

The 'digital divide' refers to the inequalities in access, usage, and capabilities to benefit from ICTs, disproportionately affecting marginalized and vulnerable groups (Sparks, 2013). Systemic gaps limit the participation of disadvantaged communities in digital governance systems and prevent them from holding institutions accountable, which in return, undermine accountability frameworks, as vulnerable populations cannot fully engage in participatory processes or access poverty reduction initiatives (Powell et al., 2010; Sparks, 2013). With the persistence of the digital divide, digital governance risks reproducing inequalities by excluding vulnerable and underrepresented groups from decision-making processes. This exclusion may limit access to public information and hinder citizen participation in social and political governance frameworks. Addressing the digital divide is therefore central to establishing equitable and inclusive accountability systems that empower all citizens to engage with governance processes and demand transparency (Powell et al., 2010; Sharma et al., 2024).

Considering the importance of the digital divide, the degree of accountability impact is expected to depend significantly on control variables such as internet usage, human capital index, and overall digital literacy levels, which reflect citizens' ability to meaningfully engage with digital platforms. Human capital, including knowledge, skills, and digital literacy, is crucial in addressing the digital divide. As Waheduzzaman and Khandaker (2022) emphasize, a well-educated and digitally capable population enhances accountability and equitable access to digital services. GDP per capita, as Zou et al. (2023) highlight, influences democratic institutions, digital infrastructure investments, and accountability, making it crucial for understanding not only how higher income levels impact the digital divide, but also how stronger democratic institutions and reduced corruption enhance digital accountability. Consequently, the severity of the digital divide is expected to play a critical role in moderating the relationship between e-participation and digital accountability, as unequal access to technology may restrict participation and, in turn, diminish its potential to strengthen accountability frameworks. Therefore, given the significant role of the digital divide in influencing digital accountability and e-participation, our second hypothesis was:

H2: The digital divide moderates the relationship between e-participation and digital accountability, such that the positive effect of e-participation on digital accountability is stronger in contexts with lower levels of digital inequality.

The digital divide represents a multidimensional gap that combines unequal access to broadband infrastructure with disparities in digital skills and usage capacity, constraining citizens' ability to transform online participation into meaningful governance outcomes (Zhang et al., 2025). Cross-national evidence shows that the positive effect of e-participation on voice and accountability is significant only in digitally advanced settings, whereas it virtually disappears where access and skills remain weak (Mao et al., 2024). Zhang et al. (2025) further demonstrate that higher digital-skill proficiency predicts deeper and more frequent online engagement, underscoring user capacity—not mere connectivity—as the decisive component. Crucially, Pham and Nguyen (2024) find that wider gaps in access to devices, networks, and digital competence systematically reduce citizens' use of e-government services, which in turn limits citizen engagement. This pattern clarifies the mechanism behind H2: when digital inequality widens, the

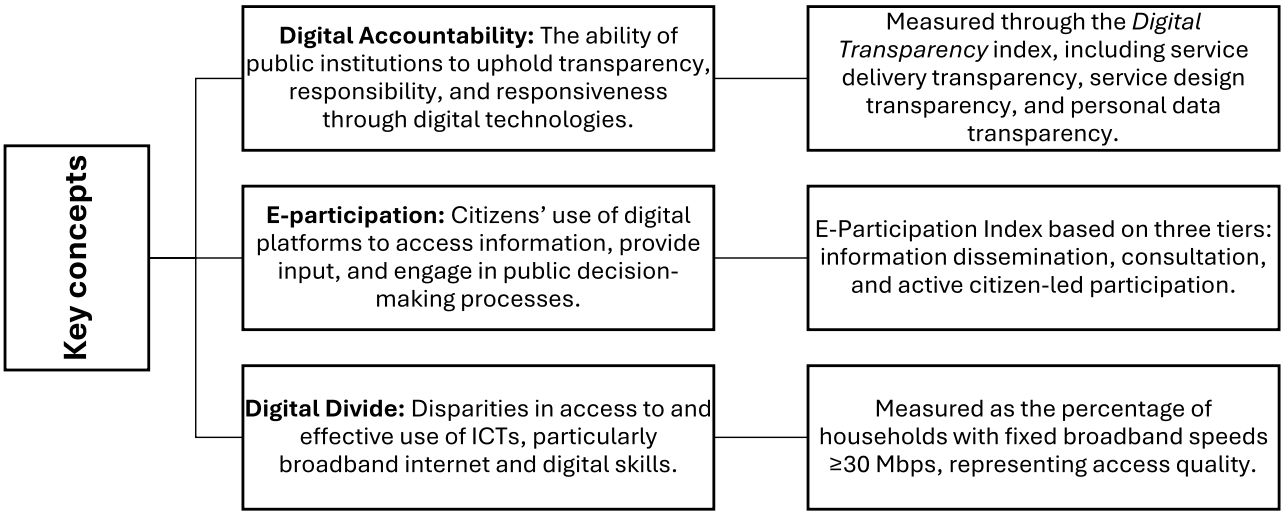


Figure 1. Definition and operationalization of key concepts.

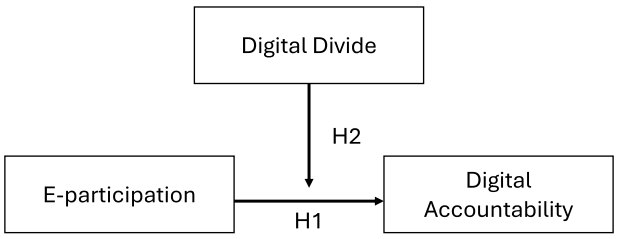


Figure 2. The digital divide moderates the effect of e-participation on digital accountability.

chain linking e-participation to digital accountability breaks at the point of citizen engagement; when access and competence converge, e-participation can flow through to effective oversight. Narrowing the digital divide is therefore not merely complementary to e-participation; rather, it is a necessary condition for its accountability potential to materialize.

To sum up, this article investigates how digital accountability is influenced by e-participation and moderated by the digital divide. Broader concepts such as democracy, transparency, and public value are not addressed as standalone themes but are embedded within the study's three core constructs. Transparency is central to digital accountability (Agostino et al., 2022b; Pina et al., 2007), defined here as the capacity of institutions to act openly and responsibly through digital means. E-participation gives practical form to democratic engagement, allowing citizens to access information, provide input, and influence decisions via digital tools (Karkin & Cezar, 2024; Wirtz et al., 2018). These interactions generate public value by fostering responsiveness and inclusivity. However, the digital divide—disparities in access, connectivity, and digital skills—limits who can participate meaningfully (Mao et al., 2024; Sparks, 2013). When marginalized groups are excluded, transparency and democratic oversight are weakened, undermining the potential for accountable digital governance. Figure 1 summarizes how each concept is defined and measured in this study. Figure 2 presents the conceptual model, illustrating how e-participation enhances digital accountability and how this relationship is strengthened in contexts with lower digital inequality.

Methodology

We used a quantitative approach to analyse the relationship between e-participation, the digital divide, and digital accountability in the EU 27 from 2018 to 2022: a period marked by intensified digital transformation and increasing institutional emphasis on transparency, e-participation, and digital inclusion—especially in the wake of the Covid 19 pandemic. The EU offers a suitable context for comparative analysis due to its shared digital policy frameworks, such as the Digital Decade policy program and the Open Data Directive, ensuring regulatory coherence across member states. Moreover, the selection was also influenced by data availability, as consistent and comparable data on digital accountability, e-participation, and broadband infrastructure were only available for EU member states during this period. The selection of EU 27 countries is grounded in the high degree of institutional and policy harmonization that defines this group. The EU operates under a shared legal, economic, and regulatory framework that substantially affects national-level governance structures, digital transformation strategies, and economic outcomes. Common policies such as the Digital Agenda for Europe, the European Governance Framework, and the EU Structural and Cohesion Funds have created a relatively homogeneous policy environment that facilitates comparative cross-country analysis (EC, 2020). This degree of integration makes the EU 27 an appropriate and coherent empirical setting for testing the relationship between e-governance and digital accountability.

The period we covered (2018–2022) was marked by accelerated digital transformation and governance reforms, both in response to long-term strategic goals and as a reaction to major external shocks such as the Covid 19 pandemic. These years also witnessed intensified efforts by EU institutions and member states to enhance transparency, citizen participation, and administrative efficiency through digital technologies (OECD, 2020; UN, 2022; OECD, 2024). Moreover, the availability of data for key indicators during this period enables robust and comparable analysis across the EU 27 countries.

However, this focus also introduces limitations. The findings are based on high-income, institutionally developed countries. They may not be directly

generalizable to developing economies or non-EU contexts where digital infrastructure, governance capacity, and civic engagement dynamics differ significantly. Additionally, the analysis relies on country-level data, which may mask important regional or socio-demographic inequalities in digital access and participation. Despite these constraints, the conceptual framework—emphasizing the interaction between e-participation and the digital divide—remains relevant beyond the EU, particularly for countries aiming to design inclusive and equitable digital governance strategies.

Heteroscedasticity, or non-constant variance in error terms, renders Ordinary Least Squares (OLS) estimator inefficient, while autocorrelation can lead to correlated residuals across observations, further undermining the accuracy of parameter estimates. The covariance matrix of the coefficients becomes inconsistent, leading to incorrect standard errors and invalid statistical inferences (Wooldridge, 2012). Given the prevalence of these issues in real-world data, relying solely on OLS can result in biased conclusions and highlights the need for alternative techniques. To address the limitations of OLS, particularly in the context of panel data, this study employs Feasible Generalized Least Squares (FGLS). FGLS estimation is a robust technique designed to address heteroscedasticity and autocorrelation, common issues in panel data. Unlike OLS, which assumes homoscedastic and uncorrelated errors, FGLS accounts for the structure of the error terms by estimating a variance-covariance matrix, resulting in more efficient and unbiased parameter estimates (Hansen & Penland, 2007). Panel data often exhibits cross-sectional variation (for example across countries or regions) and temporal shocks, leading to heteroscedasticity and autocorrelation. By systematically accounting for heteroscedasticity, serial correlation, and cross-sectional variation, FGLS produces more accurate and efficient estimators. FGLS addresses these complexities by incorporating a weighting matrix that reflects the variance-covariance structure of the errors. This matrix assigns greater weight to observations with smaller variances, ensuring the reliability of regression estimates (Parks, 1967; Bai et al., 2021).

In our empirical analysis, similar to Mao et al. (2024), we constructed the following panel model:

$$dig_acc_{it} = \delta_{0i} + \delta_{1it} + \beta_{1i} e_par_{it} + \beta_{2i} dig_div_{it} + \beta_{3i} tel_infra_{it} + \beta_{4i} hdi_{it} + \beta_{5i} income_{it} + \varepsilon_{it}$$

where *dig_acc* represents digital accountability, *e_par* is e-participation, *dig_div* is the digital divide. Control variables include telecom infrastructure (PCA-derived index), human development index (HDI), and GDP per capita.

The interaction term investigates how the digital divide moderates the impact of e-participation on accountability. The following model incorporates the interaction term ($e_par_{it} * dig_div_{it}$) to capture the combined effect of e-participation and the digital divide on digital accountability:

$$dig_acc_{it} = \delta_{0i} + \delta_{1it} + \beta_{1i} e_par_{it} + \beta_{2i} dig_div_{it} + \beta_{3i}\, e_par_{it} * dig_div_{it} + \beta_{4i} tel_infra_{it} + \beta_{5i} hdi_{it} + \beta_{6i} income_{it} + \varepsilon_{it}$$

Our data were sourced from Eurostat, the UN's e-Government Knowledgebase, and the World Bank's World Development Indicators. All variables, except the interaction term, were transformed into natural logarithmic form to reduce skewness. Robustness checks were conducted using subcomponents of digital accountability (for example service delivery and personal data transparency) to ensure consistency across dimensions.

Digital transparency, employed as a proxy for digital accountability, reflects the extent to which governments provide transparent, open, and accessible information about their services, processes, policy designs, and the management of personal data. It represents a critical dimension of digital accountability, underscoring the role of public administrations in fostering trust and enabling participatory governance. The eGovernment Benchmark is a comprehensive framework designed to assess the progress of digitalization across EU member states, offering valuable insights into how governments adopt and implement digital public services. By comparing performances from a policy-driven perspective, the benchmark highlights areas of improvement and fosters the adoption of e-government practices. Unlike frameworks focusing on compliance with specific legislative measures such as the General Data Protection Regulation or the eIDAS Regulation, the eGovernment Benchmark emphasizes key performance dimensions that drive broader digital transformation goals.

A central aspect of this evaluation was transparency, which measures how effectively public administrations provide clear and accessible information about their services, policy-making processes, and data management practices. Transparency is a key factor in assessing the effectiveness of e-government initiatives and is central to promoting digital accountability.

We measured through three interconnected components: the first was transparency of service delivery, evaluating how clearly governments define and communicate their service processes and manage user expectations, ensuring that citizens understand how services are provided and what they can expect from public institutions. The second component, transparency of service design, assessed how citizens are informed about and involved in creating policies and services, highlighting the importance of participatory governance and user engagement in shaping digital services. Finally, transparency of personal data examined whether citizens have access to and control over their data held by government organizations, ensuring that governments handle such data responsibly and in line with privacy expectations. Together, these components provide a comprehensive framework for understanding and improving the openness and accountability of public administration in the digital age (Polzer & Öner, 2025; Agostino et al., 2022b). This diverse approach ensures transparency fosters trust between governments and citizens and enhances e-government practices' inclusivity and effectiveness. Since digital transparency refers to the extent to which public administrations offer clear, accessible, and open information about their services, processes, and policies, thereby ensuring that citizens are well-informed and empowered, it serves as an indicator of digital accountability. For the robustness check, the subcomponents of digital accountability—specifically, the transparency of service delivery and the transparency of personal data—were used as dependent variables.

E-participation, developed as a complementary measure within the United Nations e-Government survey (2022), provides a critical framework for assessing citizen engagement in governance processes. This index is structured around a three-tiered model, encompassing information dissemination, consultation, and active citizen-led participation, capturing the degree of public engagement in digital governance processes. The first tier focuses on governments providing information to their constituents, forming the foundation for informed engagement. The second tier emphasizes consultation, enabling two-way communication where citizens provide feedback and input on governance matters. The third and most advanced stage involves active participation, where citizens assume a central role in shaping and influencing policy-making processes (Karkin & Cezar, 2024). This highest level of engagement reflects the principles outlined in the UN e-participation framework, embodying a progressive vision of digital democracy that prioritizes inclusivity, transparency, and collaborative governance. E-participation thus serves as a vital tool for understanding and enhancing the democratic potential of digital governance initiatives (UN, 2024). Consequently, e-participation is employed as an independent variable in empirical analyses, facilitating the evaluation of its influence on the effectiveness and inclusivity of digital governance initiatives.

The digital divide represents the disparities in access to digital resources, particularly digital literacy and high-speed internet, across populations (Zhang et al., 2025). It is a critical measure of inclusivity and equity in the digital transformation process, reflecting the extent to which households are equipped to participate in the digital economy and society. Addressing the digital divide is a priority for the EC, as it significantly impacts the ability of individuals and communities to benefit from digital advancements. The EC's vision for reducing the digital divide aligns with its broader goal of fostering a Europe fit for the digital age. This initiative emphasizes creating a fair and inclusive digital environment where technology serves people equitably. Central to this strategy is ensuring that digital transformation works for individuals and businesses while promoting a democratic and sustainable society. By addressing the digital divide, EC aims to create opportunities for all citizens to engage with and benefit from digital tools and services regardless of location or socio-economic status. As part of the Digital Decade framework, the EC has set ambitious targets to bridge the digital divide by 2030. These include providing gigabit network coverage to all European households and ensuring 5G access in all populated areas. These goals highlight the commitment to fostering equal access to digital resources and reducing disparities that hinder full participation in the digital era. Bridging the digital divide is not merely about infrastructure but creating equitable opportunities for all citizens to access information, services, and economic participation in an increasingly digitalized world. In this study, the digital divide was assessed through the proportion of households with internet speeds exceeding 30 Mbps, with higher percentages indicating reduced inequality and greater access to essential digital services.

Several control variables are included in the study to account for underlying factors that could independently affect the relationship between e-participation, the digital divide, and digital accountability. These control variables provide a broader context, helping to isolate the effects of the primary independent variables. Specifically, the study incorporates telecom infrastructure, human development, and economic development measures as control variables, each representing critical dimensions that could affect digitalization outcomes and governance practices. The telecom infrastructure index used in this study is constructed using Principal Component Analysis (PCA). As a key component of this infrastructure, Internet speed reflects the quality of digital connectivity. It plays a crucial role in ensuring equal access, particularly in addressing dimensions of the digital divide (Sparks, 2013). This statistical technique reduces the dimensionality of data while preserving its essential patterns and relationships. PCA combines multiple indicators into a single composite index, ensuring that the most significant variations across the data are captured and represented effectively. This approach simplifies the complexity inherent in multidimensional data and minimizes redundancy by accounting for correlations among the variables. For this index, four key indicators were utilized: fixed telephone subscriptions, fixed broadband subscriptions, mobile cellular subscriptions, and internet usage among individuals. By applying PCA, these indicators are aggregated into a unified measure that reflects the overall state of telecom infrastructure. The resulting index provides a robust and comprehensive measure of digital infrastructure, serving as a critical control variable to account for the foundational technological capacity that underpins digitalization efforts.

Human development is well represented by the Human Development Index (HDI), which integrates data on health, education, and income. Combining life expectancy, years of schooling, and gross national income per capita into a single composite score, the HDI provides a holistic perspective on human well-being and its correlation with digital advancements. As a control variable, HDI captures differences in socio-economic development, which may influence both e-participation and digital accountability outcomes. Economic development plays a vital role in analysing the dynamics of digital transformation and governance. We measured this through GDP per capita, which represents the aggregate economic output produced per individual within a population. This indicator provided valuable insights into the financial resources that support or constrain digitalization initiatives, emphasizing the relationship between income levels and access to digital services. As a control variable, GDP per capita was used to account for disparities in economic resources across regions or countries, which may exert an independent influence on digital accountability and transparency outcomes. By controlling variations in economic resources, the analysis ensures a more accurate assessment of the primary relationships under investigation, minimizing potential confounding effects stemming from differences in financial capacity.

The data and their sources utilized in this study are detailed in Table 1. All variables were transformed into their natural logarithm form except for the interaction term. The proportion of cumulative explained variance and factor loadings derived from the PCA for the telecommunication infrastructure indices in the EU 27 countries over the period 2018–2022, as well as the data used in this study, are available from the authors upon request.

Table 1. Data and resources.

Series		Resources
Digital accountability	dig_acc	Digital Decade 2024: eGovernment Benchmark, Shaping Europe's digital future https://digital-strategy.ec.europa.eu/en/library/digital-decade-2024-egovernment-benchmark
e-participation	e_par	UN E-Government Knowledgebase (UN, 2024) https://publicadministration.un.org/egovkb/en-us/About/Overview/E-Participation-Index
Digital divide	dig_div	Broadband internet coverage by technology and speed, Eurostat https://ec.europa.eu/eurostat/cache/metadata/en/isoc_cbt_esmsip2.htm
Telecom infrastructure	tel_infra	Fixed telephone subscriptions (per 100 people), fixed broadband subscriptions (per 100 people), individuals using the internet (% of the population), mobile cellular subscriptions (per 100 people), World Bank, World Development Indicator https://databank.worldbank.org/source/world-development-indicators
Human Development Index	hdi	United Nations Development Program, Human Development Reports https://hdr.undp.org/data-center/human-development-index#/indicies/HDI
GDP per capita	income	GDP per capita (constant 2015, USD) World Bank World Development Indicator https://databank.worldbank.org/source/world-development-indicators

Findings

As explained, our analysis was conducted in two stages. First, the direct effects of e-participation, the digital divide, and control variables on digital accountability were examined. Second, an interaction term was introduced to probe the conditional effects of e-participation and the digital divide on digital accountability. The interaction term, defined as the product of e-participation and the digital divide, captured the moderating effect of the digital divide on the relationship between e-participation and digital accountability. The estimated results are presented in Tables 2 and 3. The models presented in Tables 2 and 3 progressively incorporate control variables to assess the robustness and reliability of the findings. The last column in each table represents the whole model, including all independent and control variables, serving as the primary model for interpreting the results. Moving backward from the last column to the third and second columns demonstrates robustness by systematically removing one control variable at a time. This ensures that any single control factor does not drive the main findings. The first column in Table 2 presents a model that examines the direct relationship between e-participation, the digital divide, and digital accountability without accounting for control variables. The last column in Table 3 displays a full model investigating the indirect relationship between e-participation, the digital divide, and digital accountability with an interaction term. This stepwise approach provides a comprehensive view of the relationships under study, highlighting the stability and consistency of the results across varying model specifications.

The results in Table 2 demonstrate that both e-participation and the digital divide have a statistically significant and positive effect on digital accountability. Specifically, an increase in e-participation is associated with higher digital accountability, as reflected by significant positive coefficients across all models. The positive relationship indicates that greater public engagement in digital governance enhances digital accountability. Similarly, the digital divide, measured by the proportion of households with internet speeds exceeding 30 Mbps, shows a positive and significant impact on digital accountability in most specifications. This suggests that a lower digital divide (broader internet coverage) is associated with higher digital accountability. Among the control variables, telecom infrastructure consistently exhibits a significant positive effect on digital accountability. At the same time, human development and income have a statistically significant, in some specifications, positive influence on digital accountability.

Table 3 incorporates an interaction term to explore how the digital divide conditions the relationship between e-participation and digital accountability. The coefficients for both e-participation and the digital divide individually are negative and significant, referring to the fact that when the digital divide is at its baseline (or low), e-participation might not lead to higher digital accountability as reduced digital divide is not sufficient to leverage e-participation effectively. Similarly, when e-participation is at its baseline (or low), a reduced digital divide might not ensure higher digital accountability if people are not actively engaging. However, the interaction term is positive and statistically significant across all models. This interaction term indicates that the combined effect of e-participation and the digital divide is significantly positive. This suggests their interaction conditions the relationship between these

Table 2. Panel FGLS test results.

Variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-par	0.378230***	0.514169***	0.226539***	0.208988***
	(0.080656)	(0.083323)	(0.048475)	(0.050668)
dig_div	0.132243*	0.089675*	-0.023694	0.101590*
	(0.078757)	(0.049987)	0.059073	(0.012787)
tel_infra		0.028640***	0.015421**	0.014708**
		(0.007339)	(0.178982)	(0.006338)
hdi			2.188330***	1.166785**
			(0.178982)	(0.549111)
income				0.087416*
				(0.046698)
constant	3.689601***	3.906937***	4.552450***	3.388117***
	(0.340199)	(0.210588)	(0.260441)	(0.638455)
R^2	0.212	0.310	0.670	0.686
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; *digital acc* represents the overall score.

Table 3. Panel FGLS test results (moderation effect).

Variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-par	-1.529327***	-1.259729***	-1.001628***	-1.000977**
	(0.454284)	(0.444131)	(0.374846)	(0.389467)
dig_div	-1.764842***	-1.719268***	-1.348553***	-1.324415***
	(0.451607)	(0.446156)	(0.388223)	(0.404560)
*epar * dig div*	0.027434***	0.025376***	0.018530***	0.018517***
	(0.006576)	(0.006244)	(0.005458)	(0.005664)
tel_infra		0.033047***	0.020076***	0.020462***
		(0.008413)	(0.006176)	(0.006327)
hdi			1.995975***	1.098087**
			(0.171847)	(0.507542)
income				0.078162*
				(0.042940)
constant	9.779733***	9.776694***	8.856791***	7.849528***
	(1.461826)	(1.456483)	(1.266901)	(1.466066)
R^2	0.333	0.436	0.724	0.750
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1; *digital acc* represents the overall score.

variables and digital accountability. The findings show that the effect of e-participation on digital accountability becomes more effective as the digital divide narrows. In other words, the combination of higher e-participation and reduced digital divide (broad coverage in internet speed) amplifies the positive impact on digital accountability. Control variables, including telecom infrastructure, human development, and income, had a statistically significant and positive effect on digital accountability, indicating their complementary role in fostering a digital environment conducive to greater accountability.

For robustness analysis, panel FGLS test results using two subcomponents of digital transparency, instead of the overall digital accountability score, are presented in Tables 4, 5, 6, and 7. Tables 4 and 5 focus on the accountability of service delivery, while Tables 6 and 7 centre on the accountability of personal data. In Table 4, both e-participation and the digital divide exhibit positive and statistically significant effects on the accountability of service delivery. Also, human development and telecom infrastructure are positively associated with accountability of service delivery. In Table 5, the interaction term is introduced in the model to investigate the combined effect of e-participation and the digital divide on the accountability of service delivery. While the individual effects of e-participation and the digital divide are negative, the interaction term is positive

Table 4. Panel FGLS test results.

Variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-par	0.482809***	0.530454***	0.382774***	0.390615***
	(0.080795)	(0.092299)	(0.039235)	(0.040218)
dig_div	0.361234***	0.342983***	0.178619**	0.188393**
	(0.098644)	(0.102315)	(0.087318)	(0.086621)
tel_infra		0.010634	0.013056*	0.013762*
		(0.011851)	(0.006758)	(0.006919)
hdi			1.738053***	1.948671***
			(0.188383)	(0.642194
income				-0.019584
				(0.054619)
constant	2.542274***	2.633428***	3.493898***	3.676536***
	(0.436549)	(0.455603)	(0.402779)	(0.747358)
R^2	0.272	0.287	0.547	0.546
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1; *digital acc* represents accountability of service delivery.

Table 5. Panel FGLS test results (moderation effect).

Variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-par	-1.487929**	-1.440117**	-1.216841**	-1.202355**
	(0.584746)	(0.606534)	(0.517895)	(0.523554)
dig_div	-1.789996***	-1.799596***	-1.562992***	-1.532906**
	(0.608739)	(0.628055)	(0.554943)	(0.562543)
*epar * dig div*	0.029863***	0.029681***	0.024479***	0.024188***
	(0.008196)	(0.008465)	(0.007493)	(0.007603)
tel_infra		0.008593	0.007754	0.008042
		(0.010425)	(0.009488)	(0.009804)
hdi			1.440026***	1.359160*
			(0.194901)	(0.714040)
income				0.006612
				(0.060362)
constant	9.568532***	9.633915***	9.135238***	8.949654***
	(2.018072)	(2.081166)	(1.841914)	(2.052906)
R^2	0.442	0.460	0.488	0.474
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1; *digital acc* represents accountability of service delivery.

Table 6. Panel FGLS test results.

Variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-participation	0.025615	0.213907*	-0.012718	-0.046381
	(0.089623)	(0.117568)	(0.052363)	(0.055683)
digital divide	0.691765***	0.549670**	0.400702***	0.341972***
	(0.123266)	(0.142097)	(0.098053)	(0.098059)
telecom infrastructure		0.032974**	0.019384**	0.021620**
		(0.013888)	0.008700	(0.008682)
human development			2.677465***	0.941501
			(0.402390)	(0.861118)
income				0.132901**
				(0.051671)
constant	1.174645**	1.842691***	2.708331***	1.425009**
	(0.549106)	(0.637230)	(0.454962)	(0.661269)
R^2	0.332	0.290	0.576	0.599
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1; *digital acc* represents accountability of personal data.

Table 7. Panel FGLS test results (moderation effect).

variables	*digital acc*	*digital acc*	*digital acc*	*digital acc*
e-participation	-1.010673**	-1.482739***	-0.824816**	-0.822065**
	(0.428680)	(0.447061)	(0.385657)	(0.403333)
digital divide	-0.325566	-1.193736**	-0.426663	-0.451952
	(0.433898)	(0.507875)	(0.420386)	(0.438761)
*epar * dig div*	0.015318***	0.025336***	0.012195**	0.011761**
	(0.005591)	(0.006162)	(0.005322)	(0.005527)
telecom infrastructure		0.042014***	0.019532**	0.021702**
		(0.012432)	(0.007752)	(0.007913)
human development			2.504679***	0.935523
			(0.378453)	(0.941985)
income				0.118824**
				(0.059404)
constant	4.397882***	7.449266***	5.337103***	4.104112**
	(1.452255)	(1.740916)	(1.431854)	(1.559973)
R^2	0.376	0.431	0.633	0.644
Observations	81	81	81	81

Notes: Panel corrected standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1; *digital acc* represents accountability of personal data.

and highly significant across all models. In Table 6, the digital divide has a positive and statistically significant effect on the accountability of personal data in all model specifications. At the same time, e-participation positively influences the accountability of personal data in some specifications. Table 7 presents the results for the combined effect of e-participation and the digital divide on the accountability of personal data with the interaction term. While the individual effects of e-participation and the digital divide are negative, the interaction term is positive and highly significant across all models.

The results presented in Tables 2 and 3 align consistently with those in Tables 4, 5, 6, and 7, demonstrating the robustness of the findings across different dimensions of digital accountability. In Table 2, e-participation and the digital divide positively affect digital accountability, mirroring the positive effects observed on the accountability of service delivery and personal data in Tables 4 and 6, respectively. Similarly, the interaction term in Table 3 highlights the conditional relationship between e-participation and the digital divide on digital accountability, consistent with the findings in Tables 5 and 7, where the interaction term significantly enhances the accountability of service delivery and personal data, respectively.

Discussion

The results of this study provide significant insights into the complex nexus between e-participation, the digital divide, and digital accountability. The findings indicate that increased e-participation and a narrower digital divide independently contribute positively to digital accountability. This emphasizes the importance of fostering public engagement while ensuring equitable access to digital infrastructure. However, the significant positive interaction term highlights that the full potential of e-participation to enhance accountability is only realized when the digital divide is effectively reduced. This synergistic effect suggests that a combination of reduced digital divide and active e-participation amplifies the positive impact on digital accountability. In this context, the moderating role of decreased digital divide (broad internet speed coverage) becomes evident as it strengthens the relationship between e-participation and accountability.

The positive impact of e-participation on digital accountability aligns with the findings of Mao et al. (2024), who demonstrated that e-participation strengthens voice and accountability. However, our study reveals an additional layer: the conditional role of the digital divide. While Mao et al. (2024) emphasize the pronounced effects of e-participation in least developed countries, this research, focused on EU nations, suggests that even in developed countries, e-participation requires complementary digital infrastructure to be effective. This echoes Waheduzzaman and Khandaker (2022), who found that e-participation alone may face limitations in improving voice and accountability. Zheng (2016) identified e-participation as a driver of lower corruption levels, indirectly linking digital infrastructure to governance improvements. Similarly, this study shows that the digital divide directly

enhances digital accountability when conceptualized as internet access and quality. The findings are also parallel with the findings of Bisogno et al. (2022), who argue for the necessity of digital frameworks, such as e-government and e-participation, to achieve transparency. However, this study extends their work by demonstrating the dynamic interplay between e-participation and digital infrastructure.

The positive interaction term in this study provides a critical extension to literature. Zou et al. (2023) emphasize the heterogeneous effects of e-government across governance dimensions, with weaker effects on corruption and political stability. In contrast, this study demonstrates that narrowing the digital divide amplifies the efficacy of e-participation in improving accountability. This suggests that digital inclusion is a vital enabler for e-participation to achieve its potential.

Our findings make three important contributions to theory:

- We clarify the mechanisms through which e-participation influences accountability, showing that participation must be both technically accessible and socially inclusive to be effective. This reinforces and extends the literature on digital democracy and public value (Karkin & Cezar, 2024; Agostino et al., 2022b) by introducing infrastructure equity as a necessary condition for democratic engagement.
- The article contributes to the conceptual development of digital accountability. By using transparency subcomponents (service delivery, data handling) as empirical proxies, it operationalizes accountability in a way that can be systematically measured and compared —something that much of the existing theoretical literature (for example Waheduzzaman & Khandaker, 2022; Pina et al., 2007) has not done in the digital context.
- We introduce a moderation framework that situates the digital divide not as a background variable, but as a dynamic factor that reshapes the relationship between citizen engagement and institutional transparency, offering a conceptual lens for future studies exploring digital inclusion and governance outcomes.

Our results underscore the necessity of integrated strategies that simultaneously address digital inequality and promote participatory governance. Offering an e-government service does not necessarily lead to meaningful e-participation (Karkin & Cezar, 2024) or increased accountability (Agostino et al., 2022a). For digital governance to be effective, governments must ensure equal access and usability across diverse populations. While this study captures the digital divide primarily through internet infrastructures, specifically broadband access, digital inequalities extend beyond connectivity. They include language barriers, limited digital literacy, accessibility challenges for vulnerable populations, and incompatibility with assistive technologies (Sparks, 2013). In practice, this means that it should be just as important for governments to assess whether e-government services are being effectively used as it is to ensure they are made available. Efforts to expand infrastructure and encourage participation must be pursued in tandem; neither is sufficient alone to ensure that digital governance mechanisms enhance accountability, inclusion, and transparency.

Conclusion

Limitations

While this study contributes to understanding the mechanisms of digital accountability, several limitations remain. First, the analysis was conducted at the country level, which may obscure regional or sector-specific variations in e-participation and digital transformation outcomes. Future studies could employ sector-specific analyses—for instance, health, education, or climate resilience—to examine how digital governance initiatives align with sectoral SDGs. Second, while control variables such as telecom infrastructure and human development are considered, additional technological and institutional factors, such as AI implementation, data privacy frameworks, and institutional capacity, warrant further investigation. Lastly, the study relies on cross-sectional data, which limits the analysis of temporal dynamics. Longitudinal studies could better capture the evolution of e-participation and its impact on accountability, especially in smart governance initiatives leveraging big data and artificial intelligence. Finally, the focus on EU 27 countries limits the generalizability of the findings to non-EU and developing contexts, where digital infrastructure, governance conditions, and citizen engagement may differ substantially. Addressing these limitations will enable a more comprehensive understanding of how digital transformation policies can effectively promote transparency and equity.

Highlights

While both e-participation and improved digital access individually contribute to digital accountability, we found that their combined effect produces a significantly greater impact. Our results reveal that reducing digital disparities—measured through internet accessibility—establishes the foundational conditions necessary for meaningful citizen engagement. In turn, active e-participation amplifies digital accountability by fostering evidence-based governance, enabling citizens to monitor government actions, provide feedback, and influence decision-making processes. These findings underscore the importance of integrated policies that bridge digital access gaps while enhancing participation, facilitating the creation of responsive, inclusive, and transparent administrations capable of supporting public trust, equitable service delivery, and sustainable governance practices.

Accordingly, digital accountability can be defined as the capacity of public institutions to uphold transparency, responsibility, and responsiveness through the strategic use of digital technologies. It underscores integrating inclusive digital infrastructure and meaningful citizen participation to enable individuals to effectively monitor, evaluate, and influence governance processes. By addressing digital inequalities and fostering active e-participation, digital accountability enhances trust and equity in public administration, supporting a governance framework that is both transparent and adaptive to the demands of a digitally connected society.

Disclosure statement

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