

Sufficient and Necessary Enablers of Digitalization in Public Institutions

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Abstract—This study aims to evaluate various categories of internal and external factors contributing to the digitalization of public Romanian institutions, highlighting the minimum necessary levels that condition the digitalization process. A total of 377 responses obtained from public employees through an electronic questionnaire were analyzed. In the first step of the mixed-methods research design, the proposed relationships were examined using structural equation modeling (PLS-SEM), while additional insights into the necessary and sufficient internal and external digitalization conditions were obtained using importance-performance analysis and necessary condition analysis. The results indicate that certain external factors, such as the conditions needed for IT specialists or government clouds, and certain internal factors, such as institutions designing an appropriate IT component or assimilating innovative technologies, contribute more prominently to the digitalization processes. Postanalysis feedback from practitioners validated the quantitative results and provided additional practical relevance. Thus, from a practical perspective, the research suggests the need to develop appropriate legislative frameworks and organizational structures that encourage the digitalization of public administration. The study also offers a guide to the public sector, which will amplify the use of digital tools and technologies and further drive digitization within these institutions. From a theoretical perspective, the research fills an underexplored gap regarding public sector digitalization and complements existing international literature.

Managerial Relevance Statement—This article presents the results of a study on the influence of internal and external factors on the digital transformation of public institutions, as well as the role of external factors in ensuring internal conditions during the digitalization process. The research results identified the factors of particular importance for the digitalization of public organizations that can improve their performance and highlighted the internal and external factors that represent the minimum necessary conditions for the use of digital tools in these institutions. These insights provide guidance for policymakers, managers, and practitioners involved in the digitalization process. For policymakers involved in public administration, the results suggest policy recommendations regarding the formulation of legislative frameworks from the

perspective of data security, improving organization and coordination by including the organizational structures of administrative units to ensure both interoperability between institutions and the integration of IT components within the information system. For managers of public institutions, the research results help identify areas for improvement in organizational processes, culture, work environment, best practices in digitalization, and the implementation of digitalization strategies.

Index Terms—Digital tools (DTs), digitalization, enablers of digitalization, importance-performance analysis (IPMA), necessary condition analysis (NCA), public institutions.

I. INTRODUCTION

RECENTLY, adaptation to change and, implicitly, improvements in the provision of services by the public sector have become evident, especially due to the impetus of the COVID-19 pandemic, which created an urgent need to move most activities online [1]. In 2017, the European Parliament Briefing highlighted the importance of implementing technology to provide public services that increase administrative efficiency, along with the legislative body's active involvement in promoting e-government practices [2].

Digital tools (DTs) are increasingly used for various activities, including online technologies to promote and collaborate with the public and other institutions [3], as well as for automating routine information, allowing institutions to dedicate more time to addressing citizens' problems in a personalized way. Consequently, the need for managerial control decreases, while digital processes, management supervision, and staff creativity are encouraged [4].

In specialized literature, numerous studies address the concept of digitalization in the public sector [1], [5], [6], [7], [8], [9], [10], and Romanian researchers have also shown interest in this subject [11], [12], [13], [14], [15]. Although some of these previous studies considered factors influencing digitization [8], [9], including in the context of public institutions, they do not provide a holistic picture of the relationships between these factors, nor do they highlight their relative importance or the minimum necessary conditions to guide managerial intervention.

This study aimed to determine the extent to which internal and external factors—the key determinants of the digitalization process—influence the use of DTs in public institutions. The research also pursued two secondary objectives: 1) to identify the factors of particular importance to digitization within organizations whose actions and performance can be improved, and

Received 22 February 2024; revised 10 September 2024, 25 November 2024, and 7 March 2025; accepted 2 May 2025. Date of publication 9 May 2025; date of current version 2 June 2025. This work was supported by the Bucharest University of Economic Studies within the institutional project “Integration of digitalization opportunities in improving the management process of Romanian public institutions.” Review of this article was arranged by Department Editor F. Appio. (Corresponding author: Andreea Breazu.)

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Digital Object Identifier 10.1109/TEM.2025.3568065

2) to highlight the internal and external factors that represent the minimum necessary conditions for the use of DTs and technologies in public institutions. In line with these objectives, four research hypotheses were developed regarding the influence of internal and external factors on digitalization, the role of external factors in ensuring internal conditions for digitalization in public institutions, and the mediating role of internal factors in the relationship between external factors and the adoption of digital technologies in the public sector. A cross-sectional survey design with snowball sampling was used to fulfill the research objectives. A mixed quantitative and qualitative approach was used to conduct the study. Structural equation modeling, importance-performance analysis (IPMA), and necessary condition analysis (NCA) were used to analyze the complex relationships between exogenous and endogenous factors and their impact on the digitalization of public institutions.

The results confirm the previously mentioned research hypotheses, highlighting the factors of particular importance to digitalization within organizations whose actions and performance can be improved, as well as the factors that represent the minimum necessary conditions for using DTs and technologies in public institutions. To gain multiple perspectives on the relevance and applicability of the research results, interviews were conducted with stakeholders (policymakers and managers) from public institutions, the IT industry, and the information sector. The responses of the interviewed stakeholders confirmed the positive effects of internal and external factors on the digital transformation of organizations (with some differences in focus and vision on technical, economic, managerial, or cultural factors), including the influence of external factors on internal ones. The results obtained are not only relevant for public institutions in Romania but also for institutions in other countries undergoing the digital transformation of their public systems.

This study adds to the literature by analyzing key internal and external factors that individually contribute to the digitalization process, while also considering the synergistic effects they generate, which has not been fully explored until now. Moreover, the research considers various aspects of digitalization, integrating legal elements such as legislative provisions and psychological elements such as the evolution of mindsets regarding this process into a unified whole.

II. THEORETICAL BACKGROUND

Digitalization has become necessary for organizations, regardless of whether they belong to the public or private sector, due to the rapid assimilation of technology into their activities. Alvarenga et al. [16] showed that this technological influence has generated various challenges for organizations seeking to keep up with the transformation. Public institutions have adopted DTs and technologies to improve public engagement and interactions between citizens and public institutions, driven by external pressures [17]. Layne and Lee [18] highlighted that these advanced digital technologies can fulfill important objectives in digital governance, such as optimizing service efficiency and quality through reduced delivery times, increased transparency, and ensuring the continuity of organizational activities.

Owing to these changes, significant scientific attention has emerged regarding the conceptualization and definition of digitalization. This interest reflects a deep concern with understanding the impact and transformation of digitalization across various fields, as well as its technical, economic, and social implications. According to Bloomberg [19], digitalization involves applying digital technologies to transform a business model, thus generating new sources of income and opening up new opportunities for the organization. Buer et al. [20] stated that digitalization involves the use of digital data and technology to automate operational processes within an organization. A similar definition was provided by Frenzel et al. [21], who defined digitalization as the optimization of digital technologies to achieve efficiency, flexibility, and adaptability in operations and services.

To emphasize the differences between digitization, digitalization, and digital transformation, OECD [22, p. 5] explains that “digitization is the conversion of analog data and processes into a machine-readable format,” digitalization represents “the use of data and digital technologies as well as interconnection that results in new, or changes to existing, activities,” while digital transformation refers to the economic and societal effects of digitization and digitalization. Digitalization and digital transformation are phenomena that are not limited to the public sector but also affect cognitive models and organizational structures across different fields [23], [24].

In the literature, some publications have focused on internal and external factors that act as facilitators or barriers to digitalization. Tangi et al. [8] mentioned external factors that facilitate the digital transformation process, such as expected benefits for external actors, external pressure, and external legal obligations. Tangi et al. [9] showed that digital government transformation is influenced by several factors, including urgency, change, a collaborative environment, and a lack of political support. Nguyễn et al. [25] considered the relative advantages of digitalization, as well as observability and organizational culture, as enablers. Jain [26] identified automation, AI, and remote work as both opportunities and challenges for organizational change, noting that IoT, wireless networks, cloud computing, Big Data, AI, and blockchain form part of the digital ecosystem. Kumar [27] identified enablers such as digital infrastructure, regulations, competencies, workforce capabilities, organizational changes, service flexibility, and digital transformation strategies. Slavković et al. [28] grouped digital transformation enablers into categories including process automation, an integrated view of key operational areas, the use of analytics to improve operational decisions, and the application of digital technologies to enhance services. Haug et al. [29] identified the drivers of digital change in the public sector as technological development, economic dynamics, political, legal, and regulatory factors, and external events and crises.

Studies have generally considered internal or external enablers of organizational digitization, with relatively few focusing exclusively on the digitalization of public organizations. Not all studies have made a clear distinction between internal and external factors influencing digitalization in the public sector. In addition, some of the previously mentioned studies addressed

these factors at a very general level, without adapting or contextualizing them to the public sector's specific characteristics. Therefore, it is necessary to consider the findings of previous research that highlighted the role of certain factors, even if they did not explicitly define them as facilitators of digitalization.

Although prior studies have analyzed internal and external factors influencing digitalization and the implementation of certain DTs [8], [9], [28], [29], several research gaps remain, which this research seeks to address. For example, while some studies have examined the influence of external factors on digitalization, they have not clearly identified which factors are critical for the adoption of DTs and technologies or which performance levels need improvement. In addition, some studies failed to produce conclusive results regarding the relationship between external and internal factors—specifically, how external factors shape the internal conditions necessary for digitalization—or to identify which external or internal factors represent the minimum required conditions for using DTs.

Thus, in the following section, we explore the digital implications within public organizations and review the specifics identified in other studies related to these two categories of factors, which form the basis for developing our research hypotheses.

III. HYPOTHESES DEVELOPMENT

One primary strategy for improving processes in public entities is digitalization. Digital transformation in public institutions, also known as e-government, is a key pillar of the European Commission's strategy [30]. Twizeyimana and Andersson [31] concluded that e-governance positively influences both the services provided to citizens and institutional efficiency. The adoption of digitalization implies the use of DTs and technologies under the influence of internal and external factors. This study considers several external environmental factors, including the establishment of frameworks to meet the demand for IT specialists in public administration, the development of government clouds, the modification or consolidation of framework legislation related to e-government and digitalization, growing public concern about the ethical ramifications of the process, and improving local and national attitudes toward digitalization.

The public sector must adapt its activities and processes and effectively manage its IT systems to achieve optimal results from the digitization process [32], [33]. The rapid development of IT has led to increased human capital, new jobs in the labor market, and the acquisition of specific skills in this field [34]. Although Urbach et al. [32] emphasized the need for IT specialists, this need was not exclusively addressed as a key enabler of digitalization but rather placed within the broader context of creating specific organizational structures. Apleni and Smuts [33], based on a case study in a South African government department, highlighted the need for staff training as a critical success factor for e-government services in developing countries. Kumar [27] demonstrated that digital workforce capabilities are essential enablers of digital service transformation, with tangible effects on the quality of staff involved in the digitalization process. To support IT infrastructure development, employees in this field must be trained to effectively use DTs.

With the increasing importance of IT systems within institutions, the demand for specialists has also risen. In 2023, across the EU, approximately 10 million ICT specialists were working, representing a 4.8% proportion of all European employees [35]. Public administrations must invest in IT specialists to succeed in competitive and dynamic environments [32]. The importance of personnel as an external factor influencing digitalization was also noted in previous research, which identified the shortage of personnel as a barrier to digitalization [8]. However, these studies did not focus on the specific measures public institutions need to adopt to compete with the private sector in attracting IT specialists—especially in terms of career attractiveness and salary competitiveness—such as utilizing specialized recruitment agencies and platforms, similar to those used in the private sector (in Romania, the National Agency of Civil Servants).

One significant advancement in the IT sector in recent years has been the rise of cloud computing technology, which offers scalable, reliable, efficient, and cost-effective platforms for various activities [36], [37]. Cloud-based systems simplify data and information exchanges between governments, businesses (G2B), and government entities (G2G). Public institutions can access important data from a unified platform [38], [39]. Furthermore, they can leverage the solutions available on these platforms [40]. Numerous countries have successfully implemented and continuously upgraded government clouds, with visible impacts on public sector digitalization: the United Kingdom adopted the "Cloud First" policy, Singapore developed a private government cloud (G-cloud), and Rwanda's cloud-based services played a crucial role in saving lives during the COVID-19 pandemic [40]. However, previous studies have not sufficiently emphasized that the government cloud alone does not drive digitalization; rather, it works in conjunction with other tools and technologies (e.g., digital payments and electronic identification), as highlighted in Cangiano's research [41]. Some studies view government clouds as part of a broader trend toward recentralization of states [42], while others argue they promote both centralization and decentralization [43]. In addition to boosting economic development and improving public service delivery, cloud adoption enhances accessibility and transparency for citizens. However, ensuring data security and privacy poses a significant barrier to implementing government clouds [44], [45]. To fully embrace data-driven technologies and maximize their benefits, public institutions and companies across the EU must adopt cutting-edge cloud solutions [30].

As digitalization drives rapid change, legal frameworks must be frequently adjusted [46], [47]. Through e-government, citizens benefit from 24/7 availability and reduced costs, while public administrations experience reduced bureaucracy and increased efficiency [48]. Furthermore, governments can support Industry 4.0 integration within private sector organizations by providing fundamental policies and technical and infrastructure regulations [49]. Although previous studies addressed the role of legislation in digitalization, not all specifically identified normative legislative elements as external factors directly influencing public sector digitalization, as noted by Tangi et al. [8]. Tangi et al. [8] categorized external legal obligations as positive drivers of ICT-based transformations. While several studies highlighted

the importance of appropriate regulatory frameworks [6], [27], [29], [50], [51], few have explicitly examined how framework legislation concretely influences the adoption of DTs in the public sector.

Local governments are increasingly receptive to public input and are becoming more advanced in their approach to digitalization. To ensure effective implementation and reduce the digital divide among European nations, specific regulations should be adopted [52]. At the EU level, the application of regulations and directives related to GDPR [53], digitalization [54], and AI [55] are examples of rules shaping digitalization and DT adoption in the public sector. These regulations, once adopted at the EU level, are transposed into national legislation, requiring public sector organizations to follow specific procedures for drafting and approving these regulations—processes involving local and regional councils, mayors, managers, employees, and other relevant stakeholders.

Similarly, there is growing concern among EU citizens regarding digitalization and its ethical implications [52], [56]. New technologies and digital processes raise ethical issues around privacy [57], decision-making [58], [59], information security, and evolving moral expectations for individuals and organizations [60]. Some studies advocate for an integrated framework for ethical digitalization that combines legal, IT, and citizen perspectives [61]. These studies illustrate the ethical dimensions of digitalization, although many focus on specific ethical risks. Novotná and Kim [62] drew a parallel between the EU and South Korea in managing public health data during the COVID-19 pandemic, highlighting how Europe—constrained by GDPR—could learn from South Korea's effective use of large datasets for contact tracing, alongside transparent communication to build public trust. In addition to these theoretical discussions, numerous ethical guidelines have emerged, including UNESCO's recommendations on AI ethics [63], the U.K. Office for Artificial Intelligence's guidance for public sector AI use [64], and the OECD's principles for the ethical use of AI [65].

Since citizens directly benefit from digital public services, their perceptions and attitudes toward digitalization are critical [17]. Transparency, trust, and openness in public institutions are essential for building public confidence [66]. Digitalization has also reshaped nature, dynamics, and communication channels between citizens and institutions [67]. With an increasingly positive public attitude toward digitalization, public institutions must continuously adapt. Considering these factors, we propose the following hypothesis.

Hypothesis 1 (H1): *External environmental factors, such as (a) the creation of conditions to meet the need for IT specialists in public administration, (b) the development of the government cloud, (c) the adjustment/consolidation of e-government and digitalization framework legislation, (d) increasing societal concerns about the ethical implications of digitalization, and (e) the positive evolution of local and national mindsets regarding digitalization, have positive effects on the adoption of DTs in public institutions.*

Organizations must adequately respond to constant changes in the digital age. Because digitalization enables faster adaptation, managers should view it as a key opportunity. As part of this process, managers must foster a digital mindset and

prepare employees to face the risks associated with the adoption of digital technology [68]. Previous studies have emphasized the importance of employee skills, particularly digital and AI literacy, in the adoption of digital technologies [69], [70]. Recent research also highlights how improved employee-manager relations and workplace digitalization encourage employees to participate more actively in work-related decisions [71]. Increasingly, digitalization is treated as a strategic opportunity for organizational success [72], [73]. Jerome et al. [74] demonstrated how project managers can overcome challenges in supply chain digitalization projects, underscoring the critical role of managers in digital adoption.

The ability of various IT systems and devices to process or use transferred data, regardless of their origin, is known as interoperability [75]. Interoperability is a core element that enables digital public services, facilitates communication, streamlines procedures, and ensures seamless data flow within the government's digitalization process [76]. In public institutions, restricted data transfers can hinder technical progress and increase administrative costs. Interoperability projects in public administration aim to address challenges such as inefficient use of resources and lack of communication, ultimately supporting public sector digitalization [77].

Using a case study in Indonesia, Aminah and Saksono [78] identified nine constraints affecting governmental integration and interoperability: constitutional and legal limitations, jurisdictional issues, collaborative challenges, organizational complexities, informational barriers, managerial hurdles, cost considerations, technological constraints, and other miscellaneous factors. They noted gaps in digitalization between institutions at the central level and those at the local level, highlighting potential center-periphery conflicts and inter-organizational issues. Gil-Garcia and Sayogo [79] also showed that organizational characteristics—such as formalization, bureaucracy, and centralization—influence interoperability between public bodies, especially when conflicting agendas exist. Tonurist et al. [80] analyzed the efficiency of Estonia's X-road data exchange platform, demonstrating positive effects on the public system, including enhanced decentralization. However, they also noted interoperability challenges between the public sector and private operators, further underscoring the importance of interoperability in public sector digitalization. Potential solutions to interoperability issues include orchestration models, as discussed by Cordella and Paletti [81] in the context of Italian public administration platforms, and orchestration spaces [82]. Collaborative governance is another proposed solution, as highlighted by Chatfield and AlAnazi [83] in their case study of the Saudi Ministry Portal, which emphasized collaboration as a means to overcome intraorganizational and center-periphery conflicts. Effective interoperability supports the development of digital frameworks for citizen service delivery while guiding the factors necessary for seamless communication [84].

As previously mentioned in relation to the handling of large data volumes, the importance of a well-designed information system cannot be overstated. A properly designed information system that includes a robust IT component is essential for enabling the acceptance and use of various DTs. This is

particularly important because when IT components are integrated into information system architecture, they benefit from comprehensive support environments, including data modeling and maintenance tools [85]. Another critical aspect is data protection, especially when dealing with vast amounts of sensitive data. In the European legal context, data protection is a fundamental right, encompassing appropriate data processing practices that comply with declared purposes, legal provisions, and the informed consent of individuals [86].

Matei et al. [87] showed that a poor work environment hinders digitalization. Public institutions must therefore foster a work culture that promotes and supports digitalization. The adoption of DTs can significantly reshape work environments, altering job roles, departmental structures, and organizational needs. Digitalization must be perceived as a reliable tool and valuable asset for the institution, and its integration into various processes should be actively promoted [73].

Training and development are also crucial for successful digitalization. Without technology, it is difficult to imagine effective employee training and development in the modern workplace [88]. Matei et al. [87] emphasized the importance of DTs in modern organizations, while Wallin et al. [89] explored the link between digitalization and professional development. They found that work meaning, and self-perception are closely tied to digitalization and that potential identity imbalances can be mitigated through increased training opportunities. Managers must therefore offer frequent, high-quality training using DTs to equip employees for digital transformation.

The ability of public organizations to select and integrate modern technologies is a critical factor in their overall adaptability, particularly given the unpredictable environment in which they operate. Digitalization serves as a pathway to enhanced adaptability [90]. Organizational culture also plays a key role in DT adoption [91]. From both employee and organizational perspectives, digital technology adoption offers numerous benefits. A sustainable digital economy requires effective workforce planning, continuous skills development, and the promotion of lifelong learning cultures. However, achieving a balance between technological innovation and workforce development remains essential [87].

Therefore, we propose the following hypothesis.

Hypothesis 2 (H2): *Internal factors, such as (a) managers' perceptions of digitalization opportunities, (b) ensuring interoperability with other institutions/organizations, (c) proper design of the information system, including an IT component to support digitalization, (d) ensuring data protection, (e) fostering a work environment conducive to digitalization, (f) providing frequent, high-quality training for employees, and (g) ensuring the institution's capacity to select, integrate, and assimilate new technologies, positively influence the adoption of DTs in public institutions.*

After reviewing the literature and the approaches taken by various EU institutions, we identified that external environmental factors exert stronger influences on organizations compared to internal factors. Furthermore, the more external factors manifest, the more likely it is that internal conditions necessary for institutional digitalization will be established. The EU plays a particularly significant role by imposing standards and targets

within set timeframes [30]. Although each member state is required to allocate 20% of its Recovery and Resilience Facility funds toward digitalization—aiming to drive changes in businesses, public services, digital skills, and infrastructure—achieving these goals remains challenging, particularly in the face of immediate societal issues [92]. In addition, research suggests that successful public sector digitalization requires common objectives and uniformly applied indicators across all EU member states [13].

This exchange of influence between external and internal factors is reciprocal. The better prepared organizations are to adopt and implement digitalization, the more effectively they will utilize DTs. Strong external factors significantly shape internal readiness. When internal conditions are strengthened, the likelihood of successful DT adoption increases. Given the shared regulatory framework and clear standards at the EU level, EU policies and best practices can serve as powerful drivers of digitalization at the national level. Enhancing institutional capacity to implement and adapt digital technologies is crucial for digital transformation, provided there is sustained management commitment and sufficient resource allocation to support this organizational change.

Hypothesis 3 (H3): *The more external environmental factors manifest, the more internal conditions for the digitalization of public institutions will be ensured.*

Hypothesis 4 (H4): *Internal environmental factors mediate the effect of external factors on the adoption of DTs in public institutions. The stronger the external environmental factors, the more internal conditions will be ensured, leading to greater adoption of DTs in public institutions.*

IV. MATERIALS AND METHODS

Considering the purpose and objectives of the research, as well as the hypotheses formulated, we followed a mixed quantitative and qualitative approach. The quantitative part of the research involved processing survey data based on a questionnaire using PLS-SEM, NCA, and IPMA, complemented by postanalysis feedback from relevant stakeholders through structured interviews.

A. Data Collection

Considering that this study aimed to identify a set of sufficient and necessary external and internal enablers of digitalization in Romanian public institutions, a cross-sectional survey design with snowball sampling was used. The questionnaire was distributed in electronic format to employees of public institutions across various fields, including internal affairs, transport, justice, education, and health. The target population consisted of employees working in public institutions, regardless of their position, gender, or seniority, who provided consent to participate at the beginning of the questionnaire. Data collection took place between August and September 2023, resulting in 417 responses, of which 377 responses came from the target population and were subsequently used for data analysis. Table I presents the personal and organizational characteristics of the study sample.

TABLE I
PERSONAL AND ORGANIZATIONAL CHARACTERISTICS OF THE RESEARCH SAMPLE

Personal/organizational characteristics		N	%	Personal/organizational characteristics		N	%
Gender	Woman	128	34.0	Number of employees	< 9	5	1.3
	Man	249	66.0		10 – 49	22	5.8
Study level	High school	5	1.3		50 – 249	79	21.0
	Post-high school	5	1.3		250 – 499	119	31.6
	Bachelor's degree	102	27.1		> 500	152	40.3
	Postgraduate	87	23.1	Domain of activity	Internal Affairs	4	1.1
Seniority	PhD	178	47.2		Finance	35	9.3
	< 5 years	20	5.3		Transport and Infrastructure	6	1.6
	5–10 years	51	13.5		Justice	25	6.6
	11–15 years	55	14.6		National Defense	2	0.5
	16–20 years	123	32.6		Education	127	33.7
Managerial position	> 20 years	128	34.0		Culture	15	4.0
	Manager of the institution	24	6.4		Foreign affairs	1	0.3
	Manager of a department	97	25.7		Economy, entrepreneurship, and tourism	24	6.4
	Office Manager	25	6.6		European investments and projects	37	9.8
	Team manager	120	31.8		Development, public works, and administration	37	9.8
Annual revenue	Nonmanagerial position	111	29.4		Health	7	1.9
	< 500 000 €	9	2.4		Agriculture and rural development	5	1.3
	500 001 – 1 000 000 €	23	6.1		Energy	5	1.3
	1 000 001 – 5 000 000 €	89	23.6		Research, innovation, and digitalization	38	10.1
	5 000 001 – 10 000 000 €	86	22.8		Environment, waters and forests	5	1.3
	10 000 000 – 49 999 999 €	127	33.7		Youth and equal opportunities	1	0.3
	> 50 mil. €	43	11.4		Others	3	0.8

Source: Data collected by authors.

The qualitative step of the research involved conducting interviews with six managers/specialists from the public sector and industry (three from public institutions versus three from the IT industry) engaged in the digital transformation of public institutions regarding the results obtained in the quantitative research. The processing of the information obtained during the interviews involved the use of content analysis and allowed the identification of how specialists from the IT industry and public sector perceived the relevance and sphere of applicability of the research results.

B. Research Scales

The questionnaire included 24 questions or scales, of which only those related to DT used by employees in public institutions, external and internal enablers, and demographic variables were used.

Digitalization (ISD). To measure this concept, several DTs used in public institutions have been considered [15], [93], [94], [95], [96], [97], [98], [99], [100] such as cloud-based data management software, AI and machine learning (ML), virtual reality (VR), augmented reality (AR), digital twins, blockchain, automation solutions based on robots and drones, business intelligence, geographic information systems (GISs), and 3-D printing/3-D streaming.

The questionnaire used a Likert scale to measure participants' perceptions of several external and internal factors. Among the *exogenous factors* (FEX) were the conditions covering the need for IT specialists in public administration, the government cloud, provisions of framework legislation in e-government/digitalization, and society's concerns about the ethical implications of digitalization and the evolving mentalities and problems of society in digitalization [101], [102], [103], [104], [105]. *Endogenous factors* (FEN) include managers' perceptions of digitalization opportunities, institutional interoperability, the design of the information system, data protection, work environment, training, and the ability to assimilate or integrate modern technologies [101], [103], [104], [105].

C. Data Analysis

The data analysis strategy was designed to highlight the impact of exogenous and endogenous factors on digitalization in Romanian public institutions. To outline a more nuanced picture of these complex relationships, structural equation modeling (PLS-SEM) was used together with IPMA and NCA.

Over time, triangulation using PLS-SEM with NCA [106], [107], or IPMA [108], [109], [110] has been of interest to researchers in general, and to those in management in particular, with methodological papers and research using this methodology being published. There are various advantages, such as [111].

- 1) It facilitates the testing of theoretical aspects by combining different perspectives on causality, thus adding value to the understanding of theoretical relationships between various constructs.
- 2) It increases the usefulness of practical results; the PLS-SEM allows the identification of factors that determine the best possible result, and the NCA contributes to identifying those factors that are critical to obtain a certain result.
- 3) The multimethod approach contributes to the enrichment of research areas.

Moreover, the combined use of PLS-SEM and IPMA allows the extension of PLS-SEM results by generating additional findings and conclusions and prioritizing managerial decisions to improve a particular target construct [112].

Based on previous research and the methodology proposed by Richter et al. [111], we propose a more complex approach that involves the completion of eight steps (corresponding to PLS-SEM and NCA), to which two additional steps for IPMA are added [112] (see Fig. 1). A similar approach has been used in recently published studies [113], [114]. However, to the best of our knowledge, none of these studies has been published until the completion of this study. Moreover, for the death view, construct-level analysis was complemented by specific insights into each indicator.

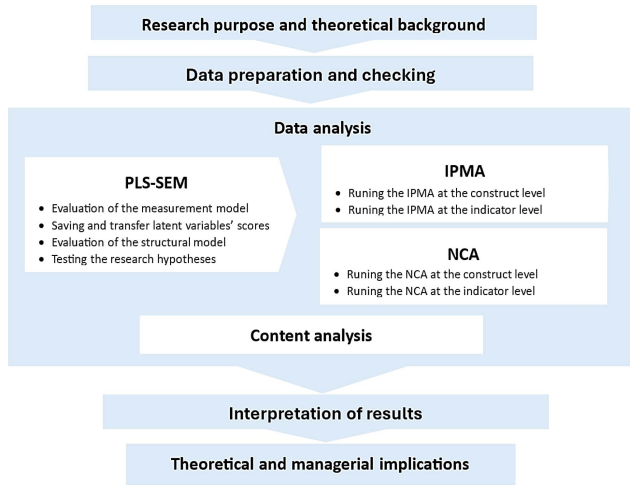


Fig. 1. Steps of the combined PLS-SEM–NCA–IPMA analysis. Source: Adapted from Richter et al. [111].

Structural equations modeling (PLS-SEM): The results of this analysis will highlight the success factors (“should have”) that can lead to the improvement of organizational performance.

NCA: Unlike PLS-SEM, which follows the logic of sufficiency (the dependent variable positively or negatively affects the dependent variable), NCA follows the logic of necessity, namely, that a certain result or level of a result can be obtained if there is a necessary cause or if it is at a certain level [115]. Moreover, the necessary conditions cannot be compensated for by each other. Therefore, if the required level of any antecedent is not achieved, the result will not occur even if the other necessary conditions are met [116]. Although no hypothesis has been formulated in this regard, the NCA highlights the combinations of minimum levels of external and internal enablers (“must-have” factors) necessary to achieve a certain level of digitalization in public institutions.

IPMA: The results of this research are not limited to highlighting the effects and minimum necessary levels of internal and external enablers; a step forward has been made, suggesting areas of specific managerial action to improve each target result through IPMA. The IPMA was created as a framework for analyzing the critical attributes of products or services to identify the areas of managerial intervention with the greatest effects on a specific outcome. The analytical framework was graphically represented using a four-quadrant matrix.

To construct the matrix, the average constructs’ scores represent their importance along the vertical axis (y), and on the horizontal axis (x)—the average path coefficients, representing their importance. For the attributes located in each of the four quadrants, a certain strategy to improve the target outcome can be proposed [117].

- 1) Quadrant I—The attributes in “keep the same direction” are important and performing.
- 2) Quadrant II—The attributes in the “focus here” quadrant are perceived as important and indicate where performance is insufficient.
- 3) Quadrant III—The attributes in the “low priority” quadrant are of low importance and also have a limited level of performance.

- 4) Quadrant IV—Attributes in “possible exceedance” have attributes with high performance and low importance.

Content analysis: Following clear coding rules, content analysis helps compress the terms analyzed into representative categories, facilitating the examination of a large volume of data in a systematic manner [118]. We conducted a content analysis to assess the accuracy and applicability of the results obtained. The data subjected to analysis were derived from six interviews with stakeholders in digital transformation, public institution managers, and digitalization specialists across various fields.

The SmartPLS version 4 application [119] was employed for the combined use of PLS-SEM, IPMA, and NCA, and the NVivo 15 software program [120] was used for content analysis.

V. RESULTS

A. Missing Data and Common Method Bias

Before the main analysis, different procedures were used to eliminate errors in the dataset. First, missing data issues were excluded because all items were mandatory in the Google Forms questionnaire. Second, common method bias (CMB) was considered using both procedural and statistical methods [121]. Therefore, the anonymity of the responses reduced the number of desirable responses, and independent and dependent questions that expressed the tendency to provide seminal responses were placed in different sections. Furthermore, Harman’s single-factor test revealed eight unrotated factors and a variance of 24.678% was explained by a single forced factor. Therefore, missing data and CMB may not be considered issues in this research.

B. Evaluation of the Model

To assess the hypotheses using partial least squares structural equation modeling, it was first necessary to evaluate the reliability and validity of the measurement model. According to Table II [122], the values of the external loadings of the three constructs are in the range of 0.558–0.825, most of which exceed the threshold of 0.7, as suggested by Hair et al. [122]. Several indicators were excluded from the initial set to obtain results. Internal consistency was measured using Cronbach’s alpha coefficient, which exceeded the optimal threshold of 0.80 [123] for each construct analyzed. Furthermore, the values of ρ_a and ρ_c were considered; all values reached thresholds above 0.70, as did the values of the average variance extracted (AVE) used to evaluate the convergent validity of the constructs, which were in the range of 0.512–0.559 and above the minimum acceptable value of 0.50 [122]. Discriminant validity was also supported by the Fornell-Larcker criterion and the HTMT (Table III).

C. Effects of Endogenous and Exogenous Factors on the Use of DT

Fig. 2 shows that FEX explains the 43.4% change in the variance of FEN, whereas, together with FEN, it leads to a 30.8% change in ISD.

Table IV presents the direct and indirect effects corresponding to the proposed hypotheses. FEX has a positive impact on ISD ($\beta = 0.222$, $p < 0.001$) and FEN ($\beta = 0.659$, $p < 0.001$),

TABLE II
EVALUATION OF THE RELIABILITY AND CONVERGENT VALIDITY OF THE MEASUREMENT MODEL

Item	Indicator	Loadings	Cronbach h Alpha	rho_a	rho_c	AVE
Internal factors (FEN) [101], [103], [104], [105]						
Managers perceive the opportunities of digitalization	FEN1	0.628	0.838	0.853	0.879	0.512
Interoperability with other institutions/organizations is ensured	FEN4	0.797				
The information system is well designed, with an IT component suitable for digitalization	FEN5	0.825				
The institution's data protection is ensured	FEN6	0.728				
The working environment within the institution is conducive to digitalization	FEN7	0.558				
The training of the organization's staff is of high quality and is conducted frequently	FEN9	0.753				
The institution has the ability to select, integrate and assimilate modern technologies	FEN10	0.684				
External factors (FEX) [101], [103], [104], [105]						
Are created conditions to cover the need for IT specialists at the level of public administration	FEX3	0.676	0.792	0.800	0.857	0.546
CloudGovernment is developed	FEX4	0.762				
The provisions of the framework legislation in the field of e-government/digitalization are adjusted/strengthened	FEX5	0.765				
Society's concerns about the ethical implications of the digitalization process are growing	FEX9	0.700	0.785			
Mentalities regarding digitalization at local/national level are in a positive evolution	FEX10	0.785				
Use of DT (ISD) [15], [93], [94], [95], [96], [97], [98], [99], [100]						
To what extent do you think the following tools specific to digitalization are now used in the processes in your institution?			0.912	0.917	0.927	0.559
Cloud-based data management software	ISD1	0.684				
Artificial intelligence (AI) and ML	ISD2	0.739				
VR	ISD5	0.649				
AR	ISD6	0.787				
Digital twin	ISD8	0.784				
Blockchain	ISD11	0.793				
Automation solutions based on robots and/or drones	ISD14	0.809				
Business intelligence	ISD15	0.728				
GISs	ISD16	0.704				
3-D Printing/ 3-D Streaming	ISD17	0.780				

rho_a, exact reliability coefficient; rho_c, composite reliability; AVE, average variance extracted. Source: Authors' calculations using SmartPLS 4 [119]. To evaluate discriminant validity (see Table III), the Fornell-Larcker criterion and heterotrait-monotrait correlation ratio (HTMT) were used [124]. The results 11 show that the average variance for the three constructs of the model was not greater than that of the other constructs. The resulting HTMT ratios were significantly lower than the recommended limit of 0.85 [122].

TABLE III
EVALUATION OF DISCRIMINANT VALIDITY

Latent construct	Fornell-Larcker Criterion			HTMT		
	FEN	FEX	ISD	FEN	FEX	ISD
FEN	0.716					
FEX	0.659	0.739		0.797		
ISD	0.529	0.475	0.748	0.594	0.541	

Source: Authors' calculations using SmartPLS 4 [119].

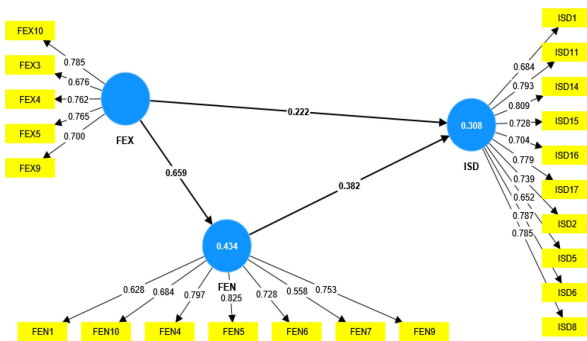


Fig. 2. Structural model. Source: Authors' conception using SmartPLS 4 [119].

supporting H1 and H3. Moreover, FEN positively affects ISD ($\beta = 0.382, p < 0.001$), validating H2. Regarding indirect effects (see Table IV), the bootstrap procedure with 5000 subsamples indicates a mediating relationship between FEX and ISD, mediated by FEN ($\beta = 0.252$, 95% BCCI [0.184, 0.323]), which confirms H4, such as internal factors complement the effect of FEX on using DT in public organizations.

Furthermore, regarding the effect size, FEX ($f^2 = 0.040$; $p < 0.05$) and FEN ($f^2 = 0.119$; $p < 0.01$) had significant but low-to-medium effects on ISD [125]. Furthermore, FEX acted directly and significantly on FEN to a degree of 0.766 ($p < 0.001$), which may be categorized as large, thereby supporting its practical relevance.

Therefore, as more attention is given to external aspects, such as creating conditions intended to cover the need for IT specialists at the public administration level, developing the government cloud, appropriately adjusting the legislative provisions in digitalization, the positively evolving mentalities regarding digitalization on the planet, local and national, as well as the factors inside the organizations, such as the managers' perception of digitalization opportunities, the appropriate design of the information system with an integrated IT component, the training of human resources, and providing protection of the institution's data, will offer significant support in using digital technologies.

D. Importance Performance Analysis

The usefulness of IPMA in the PLS-SEM model envisaged generating additional findings through a combined analysis of the two dimensions of importance and performance, providing significantly new perspectives on the role of internal and external factors influencing digitalization. The IPMA supports managerial interventions by extending the standard rapport of path coefficients (importance) and adding a dimension that considers the mean values of latent variable scores (performance) [112].

IPMA was conducted at the construct and indicator levels (see Table V), showing that to facilitate the use of DTs within organizations in the public domain, factors from the external

TABLE IV
DIRECT AND INDIRECT EFFECTS

Hypotheses	Relationships	Beta	SE	T statistic	BCCI	f^2	Decision
Direct effects							
H1	FEX → ISD	0.222***	0.057	3.894	0.127; 0.313	0.040*	Supported
H2	FEN → ISD	0.382***	0.058	6.555	0.282; 0.475	0.119**	Supported
H3	FEX → FEN	0.659***	0.035	18.676	0.594; 0.711	0.766***	Supported
Indirect effects							
H4	FEX → FEN → ISD	0.252***	0.042	5.942	0.184; 0.323	—	Supported

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; BCCI, corrected confidence interval; f^2 , effect size. Source: Authors' calculations using SmartPLS 4 [119].

TABLE V
IMPORTANCE-PERFORMANCE ANALYSIS

IPMA at construct level				IPMA at indicator level			
Construct	Importance	Performance	IPMA Quadrant	Indicator	Importance	Performance	IPMA Quadrant
External factors	0.474***	72.902	II	FEX3	0.099	75.265	II
				FEX4	0.126	72.546	II
				FEX5	0.134	72.215	II
				FEX9	0.130	75.729	I
				FEX10	0.149	69.430	II
Internal factors	0.382***	77.757	IV	FEN1	0.066	95.557	IV
				FEN4	0.092	71.950	III
				FEN5	0.086	73.077	III
				FEN6	0.074	72.944	III
				FEN7	0.056	80.040	IV
				FEN9	0.083	72.679	III
				FEN10	0.071	74.204	III

*** $p < 0.001$. Source: Authors' calculations using SmartPLS 4 [119].

TABLE VI
ANALYSIS OF THE NECESSARY CONDITIONS FOR THE USE OF DTs

NCA at construct level				NCA at indicator level			
Construct	CR-FDH	Necessary conditions		Indicator	CR-FDH	Necessary conditions	
		50.000%	100.000%			50.000%	100.000%
ISD		3.000	5.000	ISD		3.000	5.000
External factors	0.324***	2.266	3.983	FEX3	0.287***	1.699	3.487
				FEX4	0.233**	NN	4.194
				FEX5	0.216	1.262	3.330
				FEX9	0.308**	1.622	4.247
				FEX10	0.291***	NN	5.000
Internal factors	0.392***	2.549	4.469	FEN1	0.522***	2.718	4.958
				FEN4	0.272***	NN	5.000
				FEN5	0.195*	NN	4.364
				FEN6	0.316***	1.129	5.000
				FEN7	0.315*	1.301	5.000
				FEN9	0.257***	1.324	4.018
				FEN10	0.205	1.249	3.193

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Source: Authors' calculations using SmartPLS 4 [119].

environment should be emphasized because they denote a high level of importance and relatively low performance (Quadrant II), especially for the positive evolution of mentalities regarding digitalization at the local and national levels (FEX10) and for the appropriate adjustment of the provisions of the framework legislation in e-government and digitalization (FEX5). Furthermore, considering that internal factors are less important, they are not priorities for improvement (Quadrants III and IV).

E. Necessary Conditions for Using DT

NCA was used to identify the necessary sets of conditions concerning the internal and external factors required to achieve

a certain level of digitalization of public institutions [111], [126]. This analysis complements traditional approaches and focuses on the necessary levels of unique determinants and their combinations [127].

Based on the NCA conducted at the construct and indicator levels (see Table VI), FEX ($d = 0.392$) and FEN ($d = 0.324$) were both necessary conditions for the use of DTs in public institutions ($p < 0.001$).

At the indicator level related to FEX, the results show that to reach at least 50% of the DTs in public institutions, the conditions intended to cover the need for IT specialists at the public administration level (FEX3) must reach a minimum level of 1.699 points on a scale from 1 to 5, and the increase in society's

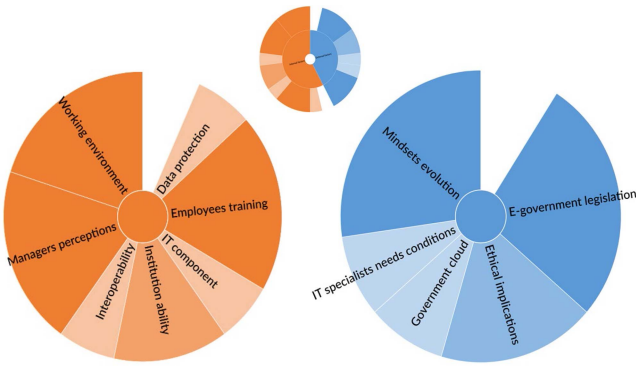


Fig. 3. Content analysis results—beneficiaries of TD. Source: Authors using NVivo 15 [120].

concerns regarding the ethical implications of the digitalization process (FEX9) must reach 1.622. Moreover, for the ISD to achieve 100%, it is essential that (cumulatively) the factors FEX3, FEX4, FEX9, and FEX10 be at least 3.487, 4.194, 4.247, and 5.000, respectively.

Considering FEN-associated indicators, reaching a threshold of 50% of digital technologies within public organizations, managers' perception of digitalization opportunities (FEN1), ensuring data protection of the institution (FEN6), the work environment conducive to digitalization (FEN7), and the frequent training of the organization's staff (FEN9) were found as necessary conditions, at least at levels 2.718, 1.129, and 1.301, and respectively 1.324, on a scale of 1–5. Furthermore, to ensure 100% digital technologies, the internal factors FEN1, FEN4, FEN6, FEN7, and FEN9 must reach the following minimum values: 4.958, 5.000, 5.000, 5.000, 5.000, and 4.018, respectively.

F. Postanalysis Feedback From Practitioners

To highlight stakeholder attitudes towards the results of the research, content analysis [118] was conducted using the NVivo 15 software program [120]. Six structured interviews were conducted with people directly involved in the digitalization process of public institutions, three of which were represented by the beneficiaries of this phenomenon, people with managerial positions who direct the strategic integration of digital transformation, and three of them represented by field specialists from the areas of cybersecurity, software and applications project management, and artificial intelligence. At the beginning of the interviews, the specialists were asked about the positive effects of internal and external factors on the digital transformation of public institutions.

Fig. 3 presents the balance of power established by the beneficiaries of digital transformation processes between the internal and external factors studied.

First, a higher share of endogenous factors (in red) supporting the use of DTs in public institutions is noted. Simultaneously, the intensity of the representative color for each category denotes the hierarchy of their evaluation regarding the importance of each chosen factor. Among the endogenous factors (red color), perceptions of digitalization enablers by managers, providing a

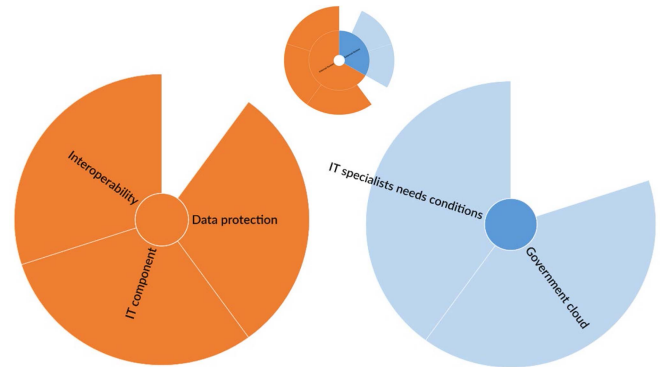


Fig. 4. Content analysis results—providers of TD. Source: Authors using NVivo 15 [120].

working environment conducive to digitalization, and facilitating quality and frequent training of employees are ranked first, followed by the ability of the institution to select, integrate, and assimilate new technologies, which has a positive effect on the adoption of DT in public institutions. Third, in their opinion, there is data protection, proper design of the information system, including an IT component to support digitalization, and interoperability with other institutions or organizations.

Regarding the exogenous factors (blue color), the positive evolution of local/national mindsets on digitalization and the adjustment/consolidation of the provisions of e-government/digitalization framework legislation are highlighted. Moreover, interviewees pointed out concerns regarding the ethical implications of the digitalization process, while the creation of conditions for meeting the need for IT specialists in public administration and the development of the government cloud are less important digitalization drivers in interviewed DTs beneficiaries' view.

Even if it resembles the results on internal factors that facilitate the digitalization of public institutions (see Fig. 4), specialists have a more concrete point of view, highlighted by simple and precise choices, especially specific to the basic processes of the professional area in which they work. All three advocate interoperability with other institutions/organizations, data protection, and proper information system design, including an IT component to support digitalization as internal drivers. Exogenous factors did not show unanimous evaluation, such as creating conditions for meeting the need for IT specialists in public administration and the development of the government cloud, each being mentioned by two interviewed specialists.

The six respondents were also questioned about the research results, which suggest that the more external environmental factors manifest themselves, the more internal conditions for the digitalization of public institutions will be ensured. All six respondents agreed that the research results corresponded to the reality in public institutions, giving concrete examples of external factors (i.e., pressure from external environmental developments, legislation, technological developments, investments in the government cloud, and evolving mindsets) that constitute both pressure and opportunities for digitalization and digital transformation. In this regard, the first interview

respondent indicated that “external environmental factors act as a catalyst that determines and supports institutions in developing solid internal conditions essential for a successful digital transformation.” The sixth interview respondent mentioned that “in practice, we have observed that when external factors are well aligned and support digital transformation, this creates a domino effect that stimulates the development of the necessary internal conditions.”

In the fourth question, respondents were asked whether the results obtained in the research were relevant from both a conceptual-theoretical point of view and from the perspective of practical implications, only for public institutions in Romania or also applicable to public organizations in other countries of the world. All six respondents considered the research results relevant not only for public institutions in Romania but also for organizations in the public system in other countries. Thus, the second interview respondent considered that “the external and internal factors mentioned in the research are also valid in other countries, as they reflect common needs and challenges in the digitalization process” while the fourth and fifth respondents considered that at a practical level the factors revealed by the research (integrating new technologies, recruiting and training IT specialists, adapting digital infrastructure and implementing robust security policies) are not only valid in the case of Romania but are problems faced by public institutions in other countries in the digitalization process. Considering the research results to be relevant for other countries, not just Romania, the third respondent believes that in future research, “it would be beneficial to conduct comparative studies that analyze the impact of external factors in different national contexts.”

VI. DISCUSSION

The effect of each of the factors in the external and the internal environment will be analyzed, both from the perspective of the “should have” logic, based on the specific results of the IPMA, and from the perspective of the “must have” logic, which derives from the NCA for using DT. Postanalysis feedback from specialists will also be considered.

A. External Factors

The first part of the discussion stresses the impact of factors from the external environment on the use of DT by public sector organizations. The results showed that all these influencing factors were highly important, highlighting the need to improve their performance levels.

Most of external factors are located in Quadrant II of the IPMA matrix, that suggest focusing improvement efforts on them and one (FEX9) in Quadrant I (keep the direction), suggests that the greatest effects on digitalization should be directed towards:

- 1) boosting positive evolution of mentalities regarding digitalization at the local and national levels;
- 2) strengthening the framework legislative provisions in e-government;
- 3) development of cloud government; and
- 4) covering the need for IT specialists in public administration.

Therefore, we conclude that special attention given to them stimulates the digitalization of public institutions. In terms of the increasingly accentuated concerns of society regarding the ethical implications of digitalization, the IPMA suggests maintaining the present direction. Moreover, covering the need for IT specialists in public administration and society’s concerns about the ethical implications of the digitalization process are necessary conditions even for medium-level digitalization of public institutions.

Unlike previous studies [8], [9], which showed that cultural barriers do not influence digital transformation, the results of our study focused on the positive evolution of mentalities, showing their effect on DTs and the necessity of improving mindset regarding digitization at the local and national levels, thus differentiating from the results obtained by some previous research regarding the role played by individual and organizational mentality, especially flexibility and orientation towards changing mentality [128].

Compared with the results of previous studies [8], [9], the interviews conducted show that public sector managers, policy-makers, and beneficiaries of DTs attach much greater importance to the evolution of mentalities than IT specialists/managers, who are the providers of these technologies. Because they are more involved in the exploitation phase of innovative technologies, managers in public institutions have the opportunity to observe the long-term effects of changing mentalities on the effectiveness of digital technologies. Changes in mentalities and their positive evolution, especially at the national level, were achieved over the long term. However, accelerating the digitization of organizations and society requires rapid medium- or short-term changes.

The results obtained regarding strengthening the framework of legislative provisions in e-government confirm those obtained by Tangi et al. [8] regarding external legal obligations, but show a much greater influence on digitalization, especially on DTs. As in the aforementioned study, the need to improve the normative legislative framework appears to be an element of external pressure that determines the behavior of public sector organizations in the direction of adopting digitization, which can be explained by considering the tendency of personnel in this sector to react strongly to legislative changes. In addition, the results obtained agree with those obtained by Kumar [27] on how government regulations on digital transformation determine the compliance of organizations and Haug et al. [29], in which legal regulations appear as an external driver of digitally induced change. The results obtained regarding the legal framework are also in line with those of other studies, showing that the emergence of new digital technologies implies legal system updating and refinement [129]. The novelty of our research concerning the aforementioned studies confirms the importance of framework legislative provisions in e-government regarding DTs, emphasizing the need for improvement.

Furthermore, to meet the minimum necessary conditions for using digital technologies in public institutions, two aspects must be considered: 1) covering the need for IT specialists at the public administration level by establishing appropriate circumstances and 2) considering societal concerns regarding

the ethical implications of digitalization. Creating conditions to cover the need for IT specialists at the public administration level is a basic requirement because ICT experts are indispensable for the development and reliable operation of corresponding solutions [32]. Furthermore, several recent studies [87], [130] have highlighted the link between digitalization and the need for more workers with adequate digital skills in sustainable development in EU countries.

Thus, unlike other recent studies that highlight the link between digitalization and the need for more workers with adequate digital skills, such as Urbach et al. [32], Matei et al. [87], and Rîndașu et al. [130], or against other studies regarding the ethical implications of digitalization [56], the results obtained from the NCA analysis highlights the fact that these two factors constitute minimum necessary conditions for digital technologies adoption in public institutions, a reduced level of their presence affecting the entire digitization at the organizational level in the public domain.

B. Internal Factors

These factors are characterized by better performance than external factors and, simultaneously, a slightly lower level of importance. However, its essential characteristic results from the mediating relationship in which it participates and plays an explanatory role.

Similarly, to comply with the minimum necessary conditions for DTs in public organizations, four essential elements are required:

- 1) managers' perceptions of digitalization opportunities;
- 2) ensuring the protection of the institution's data;
- 3) establishing a work environment conducive to digitalization; and
- 4) frequently offering quality training to the institution's human resources.

The analysis results regarding the perception of digitalization opportunities by managers seem to agree with Kohnke [131], who considered how perceiving such opportunities is a critical success factor that facilitates digitalization and digital transformation processes. Our research shows that managers' perception of digitalization opportunities is a success factor and a minimum necessary condition that must be met to use DT in public organizations. Without managers' concerns about the identification and assimilation of opportunities offered, especially by technological developments in the digitalization field, public organizations cannot integrate the new DTs that emerge from research, development, and innovation.

The need to focus on ensuring the protection of the institution's data is in constant agreement with concerns relevant to previous studies, such as Banciu, Vevera, and Popa [12] and Romero and De Pablos-Heredero [132], ensuring that data protection is a fundamental aspect of fully embracing digitalization and DTs. In the public sector, without protecting an institution's data, organizations cannot ensure trust that provides citizens with an adequate degree of DT use, considering the amplification of society's concerns regarding ethical aspects. In addition, the interoperability and relatively low performance

in the ensemble of internal factors support the conclusions of previous studies [78] and emphasize the need to apply solutions to enhance performance in this area through orchestration [82] or collaborative governance.

Compared to previous research [12], [132], from the interviews conducted, we can observe that the issues of data protection and interoperability have a much better representation in the vision of managers and specialists in the IT industry and DTs providers. They are much more frequently placed in the position of solving complex situations of interoperability and data security of public and private organizations, and are thus much more aware of the importance of those factors.

The need to ensure a work environment conducive to digitalization corresponds to the concerns expressed by Palumbo [133], who revealed the relationship between the work environment and the digitalization of organizations. Another internal factor identified as a minimum requirement for digitalization, frequently offering quality training to the institution's human resources, is in agreement with previous research examining the relationship between digitalization and professional development [89], indicating that the training and development of human resources based on DT allows an organization to respond quickly to environmental changes [134]. Therefore, among the four internal factors mentioned previously, a new element of the research is represented by the fact that they are highlighted as the minimum necessary conditions that must be met to ensure the use of DTs.

VII. CONCLUSION

This study aims to quantify the influence of internal and external factors on the use of DT in public organizations. The research started from the knowledge stage in the specialized literature, developing four hypotheses regarding the positive effects of external and internal factors on the adoption of DT in public institutions (H1 and H2), the relationship between external and internal factors (H3), and the mediating effect of organizational factors (H4). The results obtained by applying PLS-SEM confirm the four hypotheses of this study.

The results confirm and complement those of previous studies and refute some elements (according to the elements presented in Section VI), bringing *certain elements of novelty that result from combined use of IPMA and NCA to deepen the PLS-SEM results*. Thus, the IPMA showed, as *key findings*, that a series of external factors have a high importance, which highlights the need to improve their performance levels (the positive evolution of mentalities regarding digitalization at the local and national levels, strengthening the legislative framework provisions in e-government, and the increasingly accentuated concerns of society regarding the ethical implications of the digitalization process). Our study confirms the results previously obtained by Tangi et al. [8] and Haug et al. [29] regarding legislative framework provisions in e-government, showing a much greater influence on digitalization, especially on DTs, considering that this factor is of great importance, with obvious implications for improving performance. Although previous studies [8], [9] have

shown that cultural barriers do not influence digital transformation, the results of our research seem to indicate that the positive evolution of mentalities regarding digitalization at the local and national levels is a key factor that needs improvement.

The application of the NCA highlighted, *as an element of novelty, the fact that a series of external factors* (covering the need for IT specialists at the public administration level, considering societal concerns regarding the ethical implications of digitalization) and *internal factors* (managers' perception of digitalization opportunities, ensuring the protection of the institution's data, and establishing a work environment conducive to digitalization) *have positive effects in the adoption of DT in public institutions and represent the minimum necessary conditions for the use of DT in public organizations*. The analysis results regarding the perception of digitalization opportunities confirm Kohnke [131] but show that managers' perception of digitalization opportunities represents the minimum necessary condition to be met for using DT in public organizations.

The results suggest the need to improve several external factors, given that these aspects are characterized by high importance and slightly reduced performance. Similarly, a minimum level of internal and external factors should be provided as public institutions digitalize.

The postanalysis feedback seems to indicate that from the perspectives of managers and policymakers in public institutions, managerial/cultural factors, both external (mindset evolution, e-government legislation) and internal (working environment, manager's perception, employee training), are perceived as more important in the digitalization process than technical factors. The IT specialists/managers interviewed tended to prioritize technical factors involving data protection and interoperability.

Theoretical implications. This study is among the first to consider factors specific to external and internal environments regarding the use of DT by public institutions, highlighting the mediating effect of internal factors on the relationship between the other two concepts. The results open new theoretical horizons regarding the influence of mentality dynamics on digitalization, change management, and measures to improve the performance of external factors with a high level of importance in the adoption of DT in the public sector. The need to study mentality dynamics is an important consequence of the perception of digitization because it determines the speed of adoption of digital technologies and the digital transformation of organizations. The results seem to indicate that digitalization is part of organizational change; however, between these two variables, the influence is biunivocal because certain elements of organizational change management influence digitalization as internal and external factors.

Methodological implications. External and internal enablers of public institution digitalization were evaluated by the combined use of IPMA and NCA in terms of sufficiency and necessity logic [111]. Furthermore, based on previous research employing PLS-SEM, NCA, and IPMA combined, and the methodology proposed by Richter et al. [111], we proposed an integrated approach that allows a more in-depth analysis and triangulation of results. Moreover, the construct-level analysis was complemented by specific insights into each indicator for a more nuanced view.

Practical implications. This study has two practical consequences stemming from the external and internal enablers of digitalization. The first suggests action directions for decision makers and policymakers in central and local public administration. In this regard, the results suggest that the following policy recommendations can be implemented at the level of public institutions: the formulation of legislative frameworks that consider the digital component from the perspective of specialization and data security; improving organization and coordination by including some compartments of the organizational structures of the administrative-territorial units to ensure both interoperability between institutions through an ERP-type platform and the integration of the IT component within the information system; rethinking the way public services are designed and delivered from the perspective of DTs; mainstreaming innovative approaches to public procurement that integrate DTs; funding information sessions to accelerate the change of mindsets regarding digitalization and its ethical implications, increasing the number of study and training programs for specialists to correlate the supply of IT specialists with the trend of growing demand on the labor market.

The other type focuses on the management of public institutions, which facilitate the use of DT through human resources by offering suitable training programs and providing benefits that consider the degree of performance with which they are used. For managing public institutions, based on the results, the following steps can be followed regarding amplifying the use of DTs/technologies and digitalization: the analysis and evaluation of the added value that digitalization brings to the organization in multiple aspects (including from the perspective of organizational culture); identifying elements that need to be improved at the level of the organization's processes, its culture, the work environment, good practices from the perspective of digitization; the analysis of endogenous and exogenous factors that particularly influence the digitalization of a certain public institution; the formulation and implementation of the digitization strategy, including establishing the DTs/technologies that must be adopted and integrated into the management and execution processes; staff training for digital technologies; digitalization strategy implementation and organizational change management as a result of digitalization.

The main *limitation* of this study is that it was conducted in the Romanian context, considering the cultural characteristics of the population and capturing the particularities of the public environment of Romanian institutions. However, the managers and specialists interviewed, both from public institutions and the IT field, showed that the results obtained are not limited in their area of applicability to the context of the digitalization of Romanian public institutions, but reveal common factors and elements that also influence the process of digital transformation of public organizations in other countries.

Future research on this topic should focus on the skills needed by managers to facilitate digitalization within organizations and participate in building a positive vision regarding this aspect, the skills needed by staff who integrate the digital component into the information system, and how this can beneficially impact the entire organization. In addition, considering the theoretical

implications and new theoretical horizons opened by the results and key research findings and the limitations of the research (especially those related to a single national context), future research directions should include larger studies on the dynamics of mentalities in digitization, change management, and measures to improve the performance of external factors with major importance in the adoption of DT in the public sector, and longitudinal and comparative analyses of the factors analyzed to include organizations from different countries and cultures. The need for comparative studies that analyze the impact of external factors in different national contexts was also highlighted by some of the specialists interviewed in the postanalysis feedback from practitioners.

The results have implications for future research on the digitalization of public institutions: the reorientation of research from focusing on technical and technological factors to that of sociocultural factors that determine and explain the intensity and extent of the digitization of such organizations, the need to contextualize the results through studies in other geographical and cultural areas, and analyses focused on the change management of organizations in the context of their digital transformation. Some implications for future research have been highlighted in previous digital transformation studies [23]. We believe that this approach to future research will increase the possibility of capitalizing on the new elements resulting from this research in managerial and organizational practices.

ACKNOWLEDGMENT

This work was partially conducted within the Doctoral Research program of the Bucharest University of Economic Studies.

REFERENCES

- [1] S. Staniulienė and K. Lavickaitė, "Leadership for digitalization in public sector," *Polish J. Manage. Stud.*, vol. 25, no. 2, pp. 295–307, Jun. 2022.
- [2] M. Szczepański, "The role of eGovernment in deepening the single market," 2017. Accessed: Dec. 19, 2023. [Online]. Available: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/608706/EPRS_BRI\(2017\)608706_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/608706/EPRS_BRI(2017)608706_EN.pdf)
- [3] R. Muhtaseb, "Exploring the use of digital technologies in a sample of scientific and educational institutions," in *Proc. 7th Int. Conf. Educ. New Learn. Technol.*, 2015, pp. 7598–7606.
- [4] S. Giest and N. Raaphorst, "Unraveling the hindering factors of digital public service delivery at street-level: The case of electronic health records," *Policy Des. Pract.*, vol. 1, no. 2, pp. 141–154, May 2018.
- [5] K. Fossheim and J. Lund-Tønnesen, "Digitalization of public sector organizations over time: The applicability of quantitative text analysis," *Int. Rev. Administ. Sci.*, vol. 90, no. 2, pp. 318–335, Jul. 2023.
- [6] U. Plesner and L. Justesen, "The double darkness of digitalization: Shaping digital-ready legislation to reshape the conditions for public-sector digitalization," *Sci., Technol., Hum. Values*, vol. 47, no. 1, pp. 146–173, Jan. 2022.
- [7] R. Collington, "Disrupting the welfare state? Digitalisation and the retrenchment of public sector capacity," *New Political Economy*, vol. 27, no. 2, pp. 312–328, Jul. 2021.
- [8] L. Tangi, M. Janssen, M. Benedetti, and G. Noci, "Barriers and drivers of digital transformation in public organizations: Results from a survey in The Netherlands," in *Proc. Electron. Government: 19th IFIP WG 8.5 Int. Conf.*, 2020, pp. 42–56.
- [9] L. Tangi, M. Janssen, M. Benedetti, and G. Noci, "Digital government transformation: A structural equation modelling analysis of driving and impeding factors," *Int. J. Inf. Manage.*, vol. 60, Oct. 2021, Art. no. 102356.
- [10] B. Q. Hung, N. T. H. Nham, and L. T. Ha, "The importance of digitalization in powering environmental innovation performance of European countries," *J. Innov. Knowl.*, vol. 8, no. 1, Jan. 2023, Art. no. 100284.
- [11] A. Frănilă, M. Păunescu, E. M. Nichita, and P. Lazăr, "Digitalization of Romanian public Administration: A panel data analysis At regional level," *J. Bus. Econ. Manage.*, vol. 24, no. 1, pp. 74–92, Feb. 2023.
- [12] D. Banciu, A. V. Vevera, and I. Popa, "Digital transformation impact on organization management and several necessary protective actions," *Study Inform. Control*, vol. 32, no. 1, pp. 49–56, Mar. 2023.
- [13] C. M. Proftoiu, C. I. Negoia, and A. V. Costea, "Digitalization of public administration in EU member states in times of crisis: The contributions of the national recovery and resilience plans," *Int. Rev. Administ. Sci.*, vol. 90, pp. 1–17, Jul. 2023.
- [14] E. Slabu, "Transparency and digitalization in the Public Administration of Romania," *Public Admin. Regional Stud.*, vol. 14, pp. 49–56, 2021.
- [15] I. Popa, S. C. Ștefan, A. A. Olariu, and Ș. C. Popa, "Integrating digitalization opportunities into innovative public organizations' management process," *J. Innov. Knowl.*, vol. 9, no. 4, Oct. 2024, Art. no. 100564.
- [16] A. Alvarenga, F. Matos, R. Godina, and J. C. O. Matias, "Digital transformation and knowledge management in the public sector," *Sustainability*, vol. 12, no. 14, Jul. 2020, Art. no. 5824.
- [17] I. Lindgren, C. Ø. Madsen, S. Hofmann, and U. Melin, "Close encounters of the digital kind: A research agenda for the digitalization of public services," *Government Inf. Quart.*, vol. 36, no. 3, pp. 427–436, Jul. 2019.
- [18] K. Layne and J. Lee, "Developing fully functional E-government: A four stage model," *Government Inf. Quart.*, vol. 18, no. 2, pp. 122–136, Jun. 2001.
- [19] J. Bloomberg, "Digitization, digitalization, and digital transformation: Confuse them at your peril," *Forbes*, 2018. Accessed: Jul. 21, 2022. [Online]. Available: <https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril/?sh=7d15dea42f2c>
- [20] S.-V. Buer, G. I. Fragapane, and J. O. Strandhagen, "The data-driven process improvement cycle: Using digitalization for continuous improvement," *IFAC-PapersOnLine*, vol. 51, no. 11, pp. 1035–1040, 2018.
- [21] A. Frenzel, J. C. Muench, M. T. Bruckner, and D. J. Veit, "Digitization or digitalization? - Toward an understanding of definitions, use and application in IS research," in *Proc. 27th Annu. Amer. Conf. Inf. Syst.*, 2021, pp. 1–10.
- [22] OECD, "Vectors of digital transformation," Digital Economy Papers, 2019. Accessed: Sep. 9, 2024. [Online]. Available: https://www.oecd-ilibrary.org/science-and-technology/vectors-of-digital-transformation_5ade2bba-en
- [23] F. P. Appio, F. Frattini, A. M. Petruzzelli, and P. Neirotti, "Digital transformation and innovation management: A synthesis of existing research and an agenda for Future studies," *J. Prod. Innov. Manage.*, vol. 38, no. 1, pp. 4–20, Jan. 2021.
- [24] M. C. Annosi, F. Capo, F. P. Appio, and I. Bedetti, "Unveiling micro-foundations of digital transformation: Cognitive models, routines, and organizational structures in agri-food SMEs," *Technol. Forecasting Soc. Change*, vol. 197, Dec. 2023, Art. no. 122922.
- [25] H. T. Nguyen, D. B. Grant, C. Bovis, T. T. Le Nguyen, and Y. T. H. Ma, "Digitalization in public sector in emerging economies: The enablers and inhibitors influence electronic customs in Vietnam," *Int. J. Data Netw. Sci.*, vol. 6, no. 3, pp. 921–934, 2022.
- [26] A. Jain, *Impact of Digitalization and Artificial Intelligence as Causes and Enablers of Organizational Change*. Nottingham, U.K.: Nottingham Univ. Business School, 2021.
- [27] H. Kumar, "Enablers for digital transformation of services to harness new business opportunities," *IEEE Trans. Eng. Manage.*, vol. 71, pp. 14282–14292, 2024.
- [28] M. Slavković, K. Pavlović, V. R. Depalov, T. Vučenović, and M. Bugarčić, "Effects of digital citizenship and digital transformation enablers on innovativeness and problem-solving capabilities," *Appl. Sci.*, vol. 14, no. 11, Jun. 2024, Art. no. 4827.
- [29] N. Haug, S. Dan, and I. Mergel, "Digitally-induced change in the public sector: A systematic review and research agenda," *Public Manage. Rev.*, vol. 26, no. 7, pp. 1963–1987, Jul. 2024.
- [30] European Commission, "Digital decade cardinal points," Shaping Europe's digital future, 2023. Accessed: Nov. 7, 2023. [Online]. Available: <https://digital-strategy.ec.europa.eu/en/library/cardinal-points-digital-decade-report-2023>

- [31] J. D. Twizeyimana and A. Andersson, "The public value of E-Government – A literature review," *Government Inf. Quart.*, vol. 36, no. 2, pp. 167–178, 2019.
- [32] N. Urbach et al., "The impact of digitalization on the IT department," *Bus. Inf. Syst. Eng.*, vol. 61, no. 1, pp. 123–131, Apr. 2019.
- [33] A. Apleni and H. Smuts, "An e-government implementation framework: A developing country case study," in *Proc. Responsible Des., Implementation Use Inf. Commun. Technol.: 19th IFIP WG 6.11 Conf. E-Bus., E-Serv., E-Soc.*, 2020, pp. 15–27.
- [34] A. N. C. Durnoi, C. A. Teodorescu, V. M. Vargas, and S. C. Ioanas, "Analysing EU countries' digital progress towards sustainable development goals," *Amfiteatru Econ.*, vol. 25, no. 17, pp. 692–708, 2023.
- [35] Eurostat, "ICT specialists in employment," 2023. Accessed: Nov. 12, 2023. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_specialists_in_employment
- [36] K. K. Smitha, K. Chitharanjan, and T. Thomas, "Cloud based e-governance system : A survey," *Procedia Eng.*, vol. 38, pp. 3816–3823, 2012.
- [37] B. Thuraisingham, "Cloud governance," in *Proc. IEEE 13th Int. Conf. Cloud Comput.*, 2020, pp. 86–90.
- [38] A. Tripathi and B. Parihar, "E-governance challenges and cloud benefits," in *Proc. IEEE Int. Conf. Comput. Sci. Autom. Eng.*, 2011, pp. 351–354.
- [39] European Union Agency for Cybersecurity, "Good practice guide for securely deploying governmental clouds," 2013. Accessed: Nov. 8, 2023. [Online]. Available: <https://www.enisa.europa.eu/publications/good-practice-guide-for-securely-deploying-governmental-clouds>
- [40] World Bank, "Cloud services advance digital transformation for governments," 2022. Accessed: Nov. 8, 2023. [Online]. Available: <https://www.worldbank.org/en/news/feature/2022/06/07/cloud-services-advance-digital-transformation-for-governments>
- [41] M. Cangiano, A. Gelb, and R. Goodwin-Groen, "Public financial management and the digitalization of payments," in *Proc. Public Financial Manage. Digitalization Payments*, 2019, pp. 1–30.
- [42] I. Calzada, "Citizens' data privacy in China: The state of the art of the personal information protection law (PIPL)," *Smart Cities*, vol. 5, no. 3, pp. 1129–1150, Sep. 2022.
- [43] M. Maksimova, "Modern democratic federations in the digital age: The conditions and prerequisites of electronic government (de-) centralization," 2018. [Online]. Available: <https://core.ac.uk/download/pdf/158595422.pdf>
- [44] S. Dash and S. K. Pani, "E-governance paradigm using cloud infrastructure: Benefits and challenges," *Procedia Comput. Sci.*, vol. 85, pp. 843–855, 2016.
- [45] I. Nanos, E. Papaioannou, E. Androutsou, and V. Manthou, "The role of cloud computing and citizens relationship management in digital government transformation," *Int. J. Internet Marketing Advertising*, vol. 13, no. 2, pp. 120–136, Apr. 2019.
- [46] E. W. Lubua, "E-governance and the ICT legislative framework," *Int. J. Eng. Sci.*, vol. 06, no. 3, pp. 116–121, 2017.
- [47] B. Pamungkas and M. Yusuf, "Exploring digital legislation concepts and practices: Inspiration for Indonesia City government," in *Proc. Int. Conf. Democratization Southeast Asia*, 2019, pp. 322–328.
- [48] M. Krejnos, J. Stofkova, K. R. Stofkova, and V. Binasova, "The use of the DEA method for measuring the efficiency of electronic public administration as part of the digitization of the economy and society," *Appl. Sci.*, vol. 13, no. 6, Mar. 2023, Art. no. 3672.
- [49] K. Häring, C. Pimentel, and L. Teixeira, "Industry 4.0 implementation in small- and medium-sized enterprises: Recommendations extracted from a systematic literature review with a focus on maturity models," *Logistics*, vol. 7, no. 4, Dec. 2023, Art. no. 99.
- [50] K. Pedersen, "E-government transformations: Challenges and strategies," *Trans. Government People, Process Policy*, vol. 12, no. 1, pp. 84–109, Mar. 2018.
- [51] C. Renteria, J. R. Gil-Garcia, and T. A. Pardo, "Toward an enabler-based digital government maturity framework," in *Proc. 12th Int. Conf. Theory Pract. Electron. Governance*, 2019, pp. 408–417.
- [52] M. D. Vasilescu, A. C. Serban, G. C. Dimian, M. I. Aceleanu, and X. Picatoste, "Digital divide, skills and perceptions on digitalisation in the European Union - Towards a smart labour market," *PLoS One*, vol. 15, no. 4, Apr. 2020, Art. no. e0232032.
- [53] European Parliament and The Council of the European Union, "Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data," 2016. [Online]. Available: <http://data.europa.eu/eli/reg/2016/679/oj>
- [54] European Parliament and The Council of the European Union, "Regulation (EU) 2023/2844 of the European Parliament and of the Council of 13 December 2023 on the digitalisation of judicial cooperation and access to justice in cross-border civil, commercial and criminal matters, and amending certain acts in the field," 2023. [Online]. Available: <http://data.europa.eu/eli/reg/2023/2844/oj>
- [55] European Parliament and The Council of the European Union, "Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence," 2024. [Online]. Available: <http://data.europa.eu/eli/reg/2024/1689/oj>
- [56] V. Nabbsa and C. Kaar, "Societal and ethical issues of digitalization," in *Proc. Int. Conf. Big Data Manage.*, 2020, pp. 118–124.
- [57] A. Chochia and T. Nässi, "Ethics and emerging technologies – facial recognition," *IDP. Revista d'Internet, Dret i Política*, vol. 34, pp. 1–12, Dec. 2021.
- [58] F. Osasona, O. O. Amoo, A. Atadoga, T. O. Abrahams, O. A. Farayola, and B. S. Ayinla, "Reviewing the implications of AI in decision making processes," *Int. J. Manage. Entrepreneurship Res.*, vol. 6, no. 2, pp. 322–335, Feb. 2024.
- [59] N. M. Khreisat, D. Khilani, M. A. Rusho, E. A. Karkkulainen, A. C. Tabuena, and A. D. Uberas, "Ethical implications of AI integration in educational decision making: Systematic review," *Educ. Admin.: Theory Pract.*, vol. 30, no. 5, pp. 8521–8527, May 2024.
- [60] A. Spahn, "Digital objects, digital subjects and digital societies: Deontology in the age of digitalization," *Information*, vol. 11, no. 4, p. 228, Apr. 2020.
- [61] I. Wallimann-Helmer, L. Teran, E. Portmann, H. Schubel, and J. Pincay, "An Integrated framework for ethical and sustainable digitalization," in *Proc. 8th Int. Conf. eDemocracy eGovernment*, 2021, pp. 156–162.
- [62] T. Novotná and N. K. Kim, "South Korea and the EU battling COVID-19: Shared contribution to global health governance and human security," *Asia Eur. J.*, vol. 21, no. 4, pp. 545–564, Dec. 2023.
- [63] UNESCO, "Recommendation on the ethics of artificial intelligence," 2021.
- [64] Office for Artificial Intelligence, "A guide to using artificial intelligence in the public sector," 2020. Accessed: Dec. 20, 2023. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/964787/A_guide_to_using_AI_in_the_public_sector__Mobile_version_.pdf
- [65] OECD, "OECD AI principles," 2024. Accessed: Dec. 10, 2023. [Online]. Available: <https://oecd.ai/en/ai-principles>
- [66] S. Mylenko and O. Lyulyov, "The impact of digitalization on the transparency of public authorities," *Bus. Ethics Leadership*, vol. 6, no. 2, pp. 103–115, 2022.
- [67] I. Mergel, N. Edelman, and N. Haug, "Defining digital transformation: Results from expert interviews," *Government Inf. Quart.*, vol. 36, no. 4, Oct. 2019, Art. no. 101385.
- [68] A. Benlian and I. Haffke, "Does mutuality matter? Examining the bilateral nature and effects of CEO–CIO mutual understanding," *J. Strategic Inf. Syst.*, vol. 25, no. 2, pp. 104–126, Jul. 2016.
- [69] D. Cetindamar, B. Abedin, and K. Shirahada, "The role of employees in digital transformation: A preliminary study on how employees' digital literacy impacts use of digital technologies," *IEEE Trans. Eng. Manage.*, vol. 71, pp. 7837–7848, 2024.
- [70] D. Cetindamar, K. Kitto, M. Wu, Y. Zhang, B. Abedin, and S. Knight, "Explicating AI literacy of employees at digital workplaces," *IEEE Trans. Eng. Manage.*, vol. 71, pp. 810–823, 2024.
- [71] R. Palumbo, "Improving health professionals' involvement whilst sustaining work–life balance: Evidence from an empirical analysis," *Sustainability*, vol. 12, no. 21, Nov. 2020, Art. no. 9291.
- [72] S. Q. Asad and S. Manzoor, "Effects of digitalization on management practices," *Int. J. Manage.*, vol. 12, no. 1, pp. 1665–1689, 2021.
- [73] S. Nadkarni and R. Prügl, *Digital Transformation: A Review, Synthesis and Opportunities for Future Research*, vol. 71, Berlin, Germany: Springer, 2021.
- [74] J. J. J. Jerome, V. Sonwaney, and O. N. Arunkumar, "The role of project managers in navigating digitalization in a supply chain for resilience," *Prod. Manuf. Res.*, vol. 12, no. 1, Dec. 2024, Art. no. 2291649.
- [75] P. Wegner, "Interoperability," *Assoc. Comput. Machinery Comput. Surv.*, vol. 28, no. 1, pp. 285–287, 1996.
- [76] A. Campmas, N. Iacob, and F. Simonelli, "How can interoperability stimulate the use of digital public services? An analysis of national interoperability frameworks and e-government in the European Union," *Data Policy*, vol. 4, no. 1, Jun. 2022, Art. no. e19.

- [77] G. Misuraca, E. Barcevičius, and C. Codagnone, "Exploring digital government transformation in the EU: Understanding public sector innovation in a data-driven society," *Tech. Rep. EUR 30333 EN*, 2020.
- [78] S. Aminah and H. Saksono, "Digital transformation of the government: A case study in Indonesia," *Malaysian J. Commun.*, vol. 37, no. 2, pp. 272–288, Jun. 2021.
- [79] J. R. Gil-Garcia and D. S. Sayogo, "Government inter-organizational information sharing initiatives: Understanding the main determinants of success," *Government Inf. Quart.*, vol. 33, no. 3, pp. 572–582, Jul. 2016.
- [80] P. Tonurist, V. Lember, and R. Kattel, "Joint data platforms as X factor for efficiency gains in the public sector?," 2016.
- [81] A. Cordella and A. Paletti, "Government as a platform, orchestration, and public value creation: The Italian case," *Government Inf. Quart.*, vol. 36, no. 4, Oct. 2019, Art. no. 101409.
- [82] A. M. E. Solano, "Orchestration spaces in inter-organizational developments of information infrastructures: Early orchestration of a large-scale regional interoperability infrastructure in NHS England," May 2023.
- [83] A. T. Chatfield and J. AlAnazi, "Collaborative governance matters to E-government interoperability," *Int. J. Public Admin. Digit. Age*, vol. 2, no. 3, pp. 24–44, Jul. 2015.
- [84] H. Kubicek and R. Cimander, "Three dimensions of organizational interoperability. Insights from recent studies for improving interoperability frame-works," *Eur. J. ePractice*, vol. 6, pp. 1–12, 2009.
- [85] B. Wang, "The design of an integrated information system," in *Proc. Int. Conf. Database Expert Syst. Appl.*, 1996, pp. 479–488.
- [86] European Union, "Charter of fundamental rights of the European Union," Official Journal of the European Union, 2012. Accessed: Nov. 8, 2023. [Online]. Available: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012P/TXT>
- [87] M. M. M. Matei, C. Mocanu, A. M. Zamfir, and A. Nastasa, "Implications of digitalization on skill needs in a sustainable economy," *Amfiteatru Econ.*, vol. 25, no. 17, pp. 820–836, 2023.
- [88] Cedefop, "Skills in transition: The way to 2035," 2023. Accessed: Jan. 12, 2024. [Online]. Available: <http://data.europa.eu/doi/10.2801/438491>
- [89] A. Wallin, P. Nokelainen, and M. Kira, "From thriving developers to stagnant self-doubters: An identity-centered approach to exploring the relationship between digitalization and professional development," *Vocations Learn.*, vol. 15, no. 2, pp. 285–316, 2022.
- [90] G. Vial, "Understanding digital transformation: A review and a research agenda," *Manag. Digit. Transformation*, vol. 28, no. 2, pp. 118–144, Jun. 2019.
- [91] N. Hoffman and R. Klepper, "Assimilating new technologies. The role of organizational culture," in *Global Information Systems*, R. D. Leidner and T. Kayworth, Eds., Evanston, IL, USA: Routledge, 2008, pp. 225–237.
- [92] R. Tiganasu and D. Lupu, "Institutional quality and digitalization: Drivers in accessing European funds at regional level?," *Socio-Econ. Plan. Sci.*, vol. 90, Dec. 2023, Art. no. 101738.
- [93] C. Achille, C. Tommasi, F. Rechichi, F. Fassi, and E. De Filippis, "Towards an advanced conservation strategy: A structured database for sharing 3D documentation between expert users," *Int. Arch. Photogrammetry, Remote Sens. Spatial Inf. Sci.*, vol. 42, pp. 9–16, Aug. 2019.
- [94] G.-G. Hognogi, A.-M. Pop, A.-C. Marian-Potra, and T. Someșfălean, "The role of UAS-GIS in digital era governance. A systematic literature review," *Sustainability*, vol. 13, no. 19, Oct. 2021, Art. no. 11097.
- [95] O. Juszczak and K. Shahzad, "Blockchain technology for renewable energy: Principles, applications and prospects," *Energies*, vol. 15, no. 13, Jun. 2022, Art. no. 4603.
- [96] J. Moran-Sanchez, A. Santisteban-Espejo, M. A. Martin-Piedra, J. Perez-Requena, and M. Garcia-Rojo, "Translational applications of artificial intelligence and machine learning for diagnostic pathology in lymphoid neoplasms: A comprehensive and evolutive analysis," *Biomolecules*, vol. 11, no. 6, May 2021, Art. no. 793.
- [97] G. Nissim and T. Simon, "The future of labor unions in the age of automation and at the dawn of AI," *Technol. Soc.*, vol. 67, Nov. 2021, Art. no. 101732.
- [98] H. R. Vanderhorst, S. Suresh, S. Renukappa, and D. Heesom, "Strategic framework of unmanned aerial systems integration in the disaster management public organisations of the Dominican Republic," *Int. J. Disaster Risk Reduction*, vol. 56, Apr. 2021, Art. no. 102088.
- [99] K. Yadav, A. S. Alshammari, S. A. Albakri, and A. M. Aljedaie, "Challenges faced by educational institution in Middle East to accept and implement cloud-based data storage," in *Proc. 21st Saudi Comput. Soc. Nat. Comput. Conf.*, 2018, pp. 1–7.
- [100] C.-P. Simion, C.-A. Verdes, A.-A. Mironescu, and F.-G. Anghel, "Digitalization in energy production, distribution, and consumption: A systematic literature review," *Energies*, vol. 16, no. 4, Feb. 2023, Art. no. 1960.
- [101] R. Gabryelczyk, "Has COVID-19 accelerated digital transformation? Initial lessons learned for public administrations," *Inf. Syst. Manage.*, vol. 37, no. 4, pp. 303–309, Oct. 2020.
- [102] D. H. Hagen, "The effect of digitalization on the daily use of and work with records in the Norwegian public sector," *Records Manage. J.*, vol. 33, no. 2/3, pp. 105–119, Nov. 2023.
- [103] M. M. Khurshid, N. H. Zakaria, A. Rashid, M. N. Ahmad, M. I. Arfeen, and H. M. F. Shehzad, "Modeling of open government data for public sector organizations using the potential theories and determinants—A systematic review," *Informatics*, vol. 7, no. 3, Jul. 2020, Art. no. 24.
- [104] F. Kitsios, M. Kamariotou, and A. Mavromatis, "Drivers and outcomes of digital transformation: The case of public sector services," *Information*, vol. 14, no. 1, Jan. 2023, Art. no. 43.
- [105] J. A. Marino-Romero, P. R. Palos-Sanchez, F. A. Velicia-Martin, and R. G. Rodrigues, "A study of the factors which influence digital transformation in Kibs companies," *Front. Psychol.*, vol. 13, Dec. 2022, Art. no. 993972.
- [106] I. Popa, M. M. Cioc, A. Breazu, and C. F. Popa, "Identifying sufficient and necessary competencies in the effective use of artificial intelligence technologies," *Amfiteatru Econ.*, vol. 26, no. 65, pp. 33–52, Feb. 2024.
- [107] I. Popa, S. C. Ștefan, A. A. Olariu, A. Breazu, and M. M. Cioc, "Predictors of employees' work performance in online and on-site conditions: A combined use of PLS-SEM and NCA," *Econ. Computation Econ. Cybern. Stud. Res.*, vol. 58, no. 1, pp. 265–279, Mar. 2024.
- [108] M. P. Low, C. S. Seah, T. H. Cham, and S. H. Teoh, "Digitalization adoption for digital economy: An examination of Malaysian small medium-sized enterprises through the technology–organization–environment framework," *Bus. Process Manage. J.*, vol. 28, no. 7, pp. 1473–1494, 2022.
- [109] A. L. Leal-Rodríguez, C. Sanchís-Pedregosa, A. M. Moreno-Moreno, and A. G. Leal-Millán, "Digitalization beyond technology: Proposing an explanatory and predictive model for digital culture in organizations," *J. Innov. Knowl.*, vol. 8, no. 3, Jul. 2023, Art. no. 100409.
- [110] S. C. Ștefan, I. Popa, and C. E. Mircioiu, "Lessons learned from online teaching and their implications for students' Future careers: Combined PLS-SEM and IPA approach," *Electronics*, vol. 12, no. 9, 2023, Art. no. 2005.
- [111] N. F. Richter, S. Schubring, S. Hauff, C. M. Ringle, and M. Sarstedt, "When predictors of outcomes are necessary: Guidelines for the combined use of PLS-SEM and NCA," *Ind. Manage. Data Syst.*, vol. 120, no. 12, pp. 2243–2267, 2020.
- [112] C. M. Ringle and M. Sarstedt, "Gain more insight from your PLS-SEM results the importance-performance map analysis," *Ind. Manage. Data Syst.*, vol. 116, no. 9, pp. 1865–1886, 2016.
- [113] S. Hauff, N. F. Richter, M. Sarstedt, and C. M. Ringle, "Importance and performance in PLS-SEM and NCA: Introducing the combined importance-performance map analysis (cIPMA)," *J. Retailing Consum. Serv.*, vol. 78, 2024, Art. no. 103723.
- [114] M. Sarstedt, N. F. Richter, S. Hauff, and C. M. Ringle, "Combined importance–performance map analysis (cIPMA) in partial least squares structural equation modeling (PLS–SEM): A SmartPLS 4 tutorial," *J. Marketing Analytics*, vol. 12, pp. 746–760, 2024.
- [115] J. F. Hair et al., "Executing and interpreting applications of PLS-SEM: Updates for family business researchers," *J. Fam. Bus. Strategy*, vol. 12, no. 3, Sep. 2021, Art. no. 100392.
- [116] N. F. Richter, S. Hauff, C. M. Ringle, and S. P. Gudergan, "The use of partial least squares structural equation modeling and complementary methods in international management research," *Manage. Int. Rev.*, vol. 62, no. 4, pp. 449–470, 2022.
- [117] I. K. W. Lai and M. Hitchcock, "A comparison of service quality attributes for stand-alone and resort-based luxury hotels in Macau: 3-dimensional importance-performance analysis," *Tourism Manage.*, vol. 55, pp. 139–159, 2016.
- [118] S. Stemler, "An overview of content analysis," *Practical Assessment, Res., Eval.*, vol. 7, no. 1, pp. 1–6, 2000.
- [119] C. M. Ringle, S. Wende, and J.-M. Becker, *SmartPLS 4*. Oststeinbek, Germany: SmartPLS GmbH, 2022.
- [120] Lumivero, "NVivo 15," 2025. Accessed: Feb. 15, 2025. Used with permission from Lumivero. [Online]. Available: <https://lumivero.com/products/nvivo>

- [121] P. M. Podsakoff, S. B. MacKenzie, J. Y. Lee, and N. P. Podsakoff, "Common method biases in behavioral research: A critical review of the literature and recommended remedies," *J. Appl. Psychol.*, vol. 88, no. 5, pp. 879–903, 2003.
- [122] J. F. Hair, J. J. Risher, M. Sarstedt, and C. M. Ringle, "When to use and how to report the results of PLS-SEM," *Eur. Bus. Rev.*, vol. 31, no. 1, pp. 2–24, Jan. 2019.
- [123] P. Žukauskas, J. Vveinhardt, and R. Andriukaitienė, "Exploratory Research," in *Management Culture and Corporate Social Responsibility*, London, U.K.: InTech, 2018.
- [124] J. Henseler, C. M. Ringle, and M. Sarstedt, "A new criterion for assessing discriminant validity in variance-based structural equation modeling," *J. Acad. Mark. Sci.*, vol. 43, no. 1, pp. 115–135, Jan. 2015.
- [125] J. Cohen, "Statistical power analysis," *Curr. Directions Psychol. Sci.*, vol. 1, no. 3, pp. 98–101, Jun. 1992.
- [126] P. Tiwari, R. P. S. Kaurav, and K. Y. Koay, "Understanding travel apps usage intention: Findings from PLS and NCA," *J. Marketing Analytics*, vol. 12, pp. 25–41, Oct. 2024.
- [127] J. Dul, "Identifying single necessary conditions with NCA and fsQCA," *J. Bus. Res.*, vol. 69, no. 4, pp. 1516–1523, Apr. 2016.
- [128] R. Plattfaute and V. Borghoff, "Developing digitalization mindset and capabilities: Preliminary results of an action research study," in *Proc. Innov. Through Inf. Syst. Lecture Notes Inf. Syst. Organisation*, 2021, pp. 155–161.
- [129] T. M. Choi, S. Kumar, X. Yue, and H. L. Chan, "Disruptive technologies and operations management in the industry 4.0 era and beyond," *Prod. Oper. Manage.*, vol. 31, no. 1, pp. 9–31, 2022.
- [130] S. M. Rîndaşu, L. Ionescu-Feleagă, B. Ş. Ionescu, and S. I. D. Topor, "Digitalisation and skills adequacy as determinants of innovation for sustainable development in EU countries: A PLS-SEM approach," *Amfiteatru Econ.*, vol. 25, no. 17, pp. 672–691, 2023.
- [131] O. Kohnke, "It's not just about technology: The people side of digitization," in *Shaping the Digital Enterprise*, G. Oswald and M. Kleinemeier, Eds. Berlin, Germany: Springer, 2017, pp. 69–91.
- [132] S. M.-R. Romero and C. De-Pablos-Heredero, "Data protection by design: Organizational integration," *UNIE Bus. Res.*, vol. 7, no. 2, pp. 60–71, Dec. 2018.
- [133] R. Palumbo, "Does digitizing involve desensitizing? Strategic insights into the side effects of workplace digitization," *Public Manage. Rev.*, vol. 24, no. 7, pp. 975–1000, Jul. 2022.
- [134] S. Y. Barykin, O. Rasskazova, O. Evseeva, S. Evseeva, and G. Ostapenko, "Staff training digitalization as value creation process in companies," *Int. J. Entrepreneurship*, vol. 25, no. 4S, pp. 1–17, 2021.