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Article

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Integrating digitalization opportunities into innovative public organizations' management process



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ABSTRACT

The COVID-19 pandemic has had an impact on public institutions management system which imposed a digital transformation of all processes. This study explores how integrating digitalization improves management processes within Romanian public organizations. It is based on a survey approach and on “snowball” sampling technique for collecting answers from 377 employees. The analysis was developed with structural equation modeling (PLS-SEM), prediction-oriented segmentation (PLS-POS), and multigroup analysis (PLS-MGA). The obtained results show that the digitalization of public institutions has a positive effect on all five managerial functions, namely on planning, organizing, coordinating, motivating, and controlling. The findings revealed three distinct homogenous groups of respondents using a posteriori segmentation, presenting variations in tool usage and function execution. There are multi-faceted contributions of this study: (1) in terms of theory, as it contributes to the literature by reinforcing existing knowledge; (2) in terms of methodology as it employs triangulation, and (3) in terms of practical implications by offering insights for decision-makers aiming to enhance institutional dynamics in public administration, albeit within the limitations of its geographic focus. In the last part of the paper, future research directions for integrating digitalization within public institutions are presented.

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Introduction

The fourth industrial revolution redefined automation and computerization and brought a shift in investment from tangible to intangible assets (Faucher & Houle, 2023). This revolution has been triggered by the digitization process, marking the second half of the twentieth century. Humanity has felt a considerable expansion of digital technologies in various fields such as medicine, education, and public services (Brewer et al., 2020) and experienced accelerated adoption of analog and digital technologies. The last two decades have brought diverse technologies, including mobile applications, social media platforms, artificial intelligence, and big data management; step by step, they have been implemented within organizations with the purpose of accelerating processes, increasing efficiency, and optimizing profitability (Crawford & Serhal, 2020; Iyamu et al., 2021), as well as leveraging employee skill adequacy and innovation (Rindașu et al., 2023).

Shifting from traditional production methods to adoption of analog and digital technologies, created opportunities in markets and

industries worldwide (Buck & Eder, 2018). It is considered that more challenges are yet to come, in the so-called fifth revolution characterized by changes in work dynamics due to automation (Doyle-Kent & Kopacek, 2020). Predicting the trends that will accompany it, is rather challenging. Learning new skills and implementing new security techniques will also claim for profound changes from individuals and organizations. Therefore, even digital transformation resulted from organizations need to adapt to IT advance and data processing, it become indispensable in adopting the new type of operations (Cicea et al., 2023).

It is widely believed that there is a recent event which acted as an enabling factor for the transition to digital technologies: the COVID-19 pandemic. It had a significant influence on public institutions, in the sense of operating methods reconfiguration in order to enhance service provision and increase efficiency and effectiveness. The administrative processes have been the main point of interest in relation to the implementation of digital technologies. To ensure success, this digitization must be user-oriented and address the needs and interests of the public while facilitating the use of technological solutions. (Pelset et al., 2021). The pandemic caused profound changes for companies that, in a short time, had to offer solutions based on technology as well as redesign management systems to ensure the

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involvement of everyone, with no one being excluded or left behind in the digitization process (Almeida et al., 2020).

To ensure the desired results from digital transformation, organizations may benefit from a strategic roadmap that integrates management's vision with the design and implementation of appropriate managerial actions (Ribeiro-Navarrete et al., 2023). In the context of enhancing management processes within public institutions and integrating digitalization opportunities, it can be argued that there is a difficulty in systematically synthesizing and analyzing the outcomes and the challenges triggered by this transformation. This, in fact, represents a notable research gap, even if the literature does extensively explore digitalization in public administration. However, it does not fully address managerial functions in their relationship with the management system in the public field, in order to identify those related areas needing improvements in a digital context. This is why this study aims at analyzing in what way management processes can be improved by integrating digital opportunities. In the same time, the current study will address specific concerns related to the ability of institutions to adhere to a new digital landscape. The research will adopt a confirmatory-first mixed mode approach (Sharma et al., 2024), first quantifying the effect of integrating digital tools on management processes and functions within public institutions and secondly identifying if this effect is the same for public institutions, or the digitalization process has different effects in different contexts.

In the following, we will deepen the theoretical approaches of the digitization process, with a specific focus on those characteristic of public institutions, arguments being brought in support of the effects of this transformation on each of the five functions of management and, implicitly, on the management process. The third section presents the methodological elements, including the time frame of the study, the sampling method, the scales used, as well as the data analysis methods. Section four includes the results of the research, in terms of validation of the hypotheses through structural relations, and highlighting unobserved heterogeneity, materialized in three segments with distinct characteristics. In the last part, the paper provides in-depth discussions based on the results, emphasizing implications for public institutions and the literature, as well as limitations and possible research directions.

Theoretical framework

Digitalization in public institutions

A modern technological trend of the 21st century refers to digitization and the process of digital transformation of organizations. It is reshaping the way (traditional to digital) our industry and society work today. This phenomenon is considered to be a major driving force of innovation that is causing changes to both the way public organizations and private firms operate (Lang & Lang, 2021).

Some authors (Schin et al., 2023) argue that the main reasons public institutions change the way they operate, are: to improve service provision, become more efficient and effective in applying public policies, and be actively involved in local community projects. Nevertheless, this entire process also involves digitalization. Digitalization in the public sector incorporates new ways of working with stakeholders, new services, new service delivery frameworks, and new forms of relationships (Pelse et al., 2021). According to Pelse et al. (2021), few systematic empirical studies have been conducted on how public administration institutions implement and manage digital transformation in their daily practices and what results are achieved. The same authors consider that digitization in public administration should be more focused on users, on their interests, and the ease of use.

The idea that the digital transformation cannot solve all problems, even if found either in public or private organizations or within

society, has gained the attention of authors (Fischer et al., 2021). Some of them have provided support for this and argued that in order to obtain a realistic image of the problems that digitization can address, it is necessary to study and further emphasize the impact of digitization (Fischer et al., 2021). In the public sector, this impact is closely related to specific objectives and effects that are difficult to anticipate.

In this study, public entities refer to administrative structures (at the central or local level) and economic institutions under state supervision. We define a public organization starting from the traditional meaning of the concept of an organization, as "a social entity created with the explicit aim of achieving certain objectives," with the mission of satisfying public needs (Lazăr, 2013, p.95).

Over the last decade, the importance of organizational changes within public entities has increased significantly (Soeardi et al., 2023), generating real concern regarding the establishment of functional organizational structures under a national system of laws and regulations (Lazăr, 2013). One major change public institutions faced during this period was the digital transformation process.

Brown (2005) showed that public administration has profoundly been affected by digital technologies which actually transformed the operational landscape of public services. This transformation refers to the integration of novel concepts and methods into administrative processes, and to a change in the balance of traditional public administration elements.

One of the new concepts refers to technological progress. Lazăr (2013) considers technological progress as requiring that public organizations use increasingly advanced and personalized technologies. These represent advancements which encompass the expansion of the Internet and the development of efficient methods for collecting, storing, transmitting, and using information. In the same time, they enable significant cost reductions while enhancing the quality of products and services. They also include the use of complex production equipment and the integration of robots and artificial intelligence into operating systems. The broader context of digital transformation in public administration, underlines the need for tailored technological solutions to meet specific organizational needs and improve overall performance.

Closely related to the previous concept, it appears another one: technological innovation. Pang et al. (2014) suggested that technological innovation within public sector organizations can benefit from five distinct organizational capabilities: (1) *Public Service Delivery* and assumes efficient and effective provision of public services through the use of technology, (2) *Resource Development*, which implies optimal utilization and development of resources to support technological advancements, (3) *Collaboration in Service Production*, meaning conjoint efforts among different stakeholders to enhance service production, (4) *Public Engagement*, which refers to active involvement of citizens in the governance process using digital tools and (5) *Innovation in the Public Sector*, assuming continuous development and implementation of innovative practices within the public sector. In order to determine improved service delivery and governance, all these five capabilities have to collectively contribute to the overall innovation ecosystem within public sector organizations.

Furthermore, the information technology (IT) has specific characteristics according to Reix (2002, as cited in Lazăr, 2013). They are determined by their potential impact within organizations and can be presented in six categories. The first one is *Automation*, which refers to IT digitalizing routine tasks, leading to increased efficiency and reduced human error. The second one is *Information Processing*, which refers to IT systems that enable the efficient collection, storage, and analysis of vast amounts of data, facilitating informed decision-making. The third category of IT characteristics is *Communication Enhancement*, which refers to digital tools that improve communication within and between organizations, ensuring that information is quickly and accurately transmitted. The fourth category is *Resource*

Management, which refers to IT supporting the efficient allocation and monitoring of resources, optimizing their use and reducing waste. The fifth category is called *Scalability and it* refers to IT solutions that can be scaled up or down based on organizational needs, providing flexibility in operations. The last category of IT characteristics is represented by *Innovation Facilitation*, which refers to IT fostering a culture of innovation by providing tools and platforms for collaboration and creative problem-solving.

Another concept explored by [Twizeyimana and Andersson \(2019\)](#) is digital governance, defined as the capacity of governance systems to enhance efficiency in public administration. The effect of digital governance is described as supporting more responsive, inclusive, and effective public administration. It is widely believed that the efficiency in the public administration is obtained if providing improved services to citizens and encouraging them to participate in the governance process.

Among main benefits of integrating digital technology in public institutions, one can mention boosting innovation and agility by incorporating emerging technologies, such as virtual reality, artificial intelligence, blockchain, and natural language processing ([Gong & Ribiere, 2023](#)). The culture of innovation can be fostered by exploiting digital technologies and using them in order to create environment that encourages experimentation and implementation of new ideas.

Another benefit of digital transformation is explained by [Joseph \(2015\)](#) and [Dhaoui \(2019\)](#) who have emphasized that digitizing operations can consolidate social networks, analytics, and project management into a cohesive platform, leveraging the efficient use of cloud computing, improving communication between teams and reducing isolated work. Not only communication skills can be consolidated by digital transformation, but also digital skills. [Vasilev et al. \(2020\)](#) argued that the digitization of the socioeconomic system is contingent on improving the digital competence of the population. This may be achieved through suitable programs oriented to develop citizens' digital skills.

Moving on, data transparency is considered another benefit of digital transformation, with direct impact on preventing and fighting corruption or reducing corrupt practices ([Bertot et al., 2010](#)). Data transparency is also an effective tool for public institutions as it facilitates citizens' access to information that was previously unavailable or difficult. In this regard, anyone interested can undertake checks and analyses of government and financial activities, due to greater accessibility to public data. By making data more accessible and processes more transparent, digital transformation helps hold public institutions accountable.

Depending on each economy, on its scientific and technological progress, and also on its resources, there is and will always be a different need to urge the adoption of digital technologies. In the same time, [Vasilev et al. \(2020\)](#) have raised in discussion the that is essential to study the digitalization process with the aim to diminish eventually negative effects and benefit from positive outcomes.

All in all, one can conclude that the scientific literature provides various concepts related to the digitization of public institutions over time. However, a careful evaluation of this process in its initial phase remains a major task. With multiple benefits for both public institutions and stakeholders, the evaluation precedes the successful implementation of digital technologies. Having in mind potential challenges, understanding the specific needs and contexts for implementation, and developing tailored strategies, have huge chances to mitigate risks, optimize resources, and maximize the benefits of digital transformation for public institutions and their stakeholders. As stated before, the purpose of this assessment is to identify the components that can be subjected to digitization and could potentially improve the functioning of these institutions. Consequently, the present research paper proposes carefully analyzing the implications of digitalization for the managerial processes of public institutions, including planning, organizing, coordinating, motivating, and controlling.

Implications of digitalization for the management process

Within this section, the authors analyze the impact of digitization on management processes. Since 1930, [Fayol and Coubrough \(1930\)](#) referred to management functions as activities carried out by managers to achieve organizational goals. Nowadays, [Burduş and Popa \(2018\)](#) show that the main management functions include: planning, organizing, coordinating, motivating, and controlling. There are authors considering that these functions are interdependent, and that effective management requires a balanced approach of them ([Banciu et al., 2023](#)).

Planning function

Within the scientific literature of management, it is considered that the first function of management is planning ([Burduş & Popa, 2018](#)). This function refers to managers analyzing available information, identifying relevant trends and patterns, and making predictions regarding the evolution of both internal and external environments. It is widely believed that planning is essential for strategic decision-making as it provides managers with a clear view of potential future scenarios. This will eventually enable them to prepare their organization for changes and seize opportunities.

In general, organizations struggle to adapt to a continuously evolving business environment and to find ways to respond appropriately to external changes. This is why, the planning function is critical for setting objectives, allocating resources efficiently, and guiding an organization towards its goals ([Banciu et al., 2023](#)). In the same time, it facilitates anticipating future challenges and opportunities, and also proactive decision-making and strategic planning.

Another salient aspect refers to its ability for maintaining competitiveness and ensuring long-term sustainability in a dynamic and unpredictable landscape. So, planning function along with digitization, can represent an effective way to analyze various types of data, including financial, operational, social, economic, and technological.

What is more, in the digital context, some authors believe that achieving effective planning requires not only access to real-time data but also the use of advanced analytics tools and expertise in emerging technologies ([ElMadany et al., 2021](#)). Consequently, there will be more informed decisions, future trends will easily be anticipated and changes in the business environment will be properly managed. Needless to say that these tools and methods will also be useful in forecasting customer behavior, or market trends, and even industry changes more accurately. So, these are the reasons the digitization process is seen as a promising opportunity to manage increasingly rapid changes in the environment ([Ködding et al., 2023](#)). Once with the expansion of massive data availability and emergence of digital technologies, organizations will remain agile, competitive and responsive, leveraging data-driven insights to navigate complex situations. All these arguments demonstrate that planning plays an essential role in decision-making by providing crucial information for developing appropriate strategies. Consequently, this approach contributes to aligning an organization with anticipated changes in its operating environment and strengthening its ability to adapt to new challenges. By anticipating future trends and potential disruptions, organizations can proactively adjust their strategies to ensure resilience and sustained success ([Bertot et al., 2010](#)).

Considering the above, we propose the following hypothesis:

Hypothesis 1. (H1): *The use of digitalization-specific tools influences the managerial planning function.*

Organizing function

The next function of management is the organizing function. This management function is characterized by the efficient allocation and

coordination of organizational resources to achieve organizational goals (Burduș & Popa, 2018). Consequently, the digitization process exerts several effects on the organizing function of management.

First of all, according to Matt et al. (2015), automation of operational processes brings greater efficiency in the allocation and management of resources. In addition, real-time decisions can be undertaken given the quick access to essential information, that digital technologies facilitate. There are authors discussing the fact that stakeholders' interaction changes with digital collaboration and communication platforms, strengthening the effectiveness of coordinating activities (Henderikx & Stoffers, 2022). So, it is considered that these technologies enable more efficient information flow, enhance team coordination, and improve overall organizational responsiveness.

Secondly, digitalization of some human resources activities support performant staff management. Recruitment and performance evaluation will benefit from increased flexibility, the organizational structure will adapt easier to changes in the business environment, the adjustment of activities according to fluctuating market demands will be improved (Kambur & Yildirim, 2023).

Finally, adopting digital technologies strengthens transparency in organizational processes, even if they need continuous monitoring and evaluation of their effectiveness (Phillips & Wright, 2009). Siemens (2016) highlighted that digital tools used in project management, contribute to more efficient coordination and monitoring of progress, while ensuring that deadlines are met. Digital technologies also contribute to the efficient distribution of resources according to requirements and priorities, thereby increasing organizational efficiency.

Considering the above, we propose the following hypothesis:

Hypothesis 2. (H2): *The use of digitalization-specific tools influences the exercise of the management organizing function.*

Coordinating function

The third management function is coordinating, which, according to Burduș and Popa (2018) refers to the process of harmonizing individual and group efforts to achieve organizational goals. The authors consider that it is an essential management function, aligning resources, activities, and processes to achieve organizational efficiency and effectiveness. The same authors explain that, communication is the foundation of coordination and an essential element in organizations, as it facilitates information exchange, aligns common goals, and contributes to team effectiveness and cohesion (Burduș & Popa, 2018). The smooth functioning and success of any organization is based on effective communication. It is generally agreed that in the end, communication will ensure that all members are informed, engaged, and working towards the same objectives.

However, the role of digital technologies in the communication process is understood differently, depending on the context and general beliefs. With referral to digitalization, Plotnikova et al. (2021) emphasized the importance of using online communities, highlighting them as tools that connect internal and external stakeholders. In this regard, there are to be mentioned some benefits such as: bringing together specialists with diverse expertise at various hierarchical levels; facilitating collaboration and knowledge-sharing; more effective and innovative problem-solving. Moreover, according to Daim et al. (2012), digital platforms support communication and collaboration by regardless of members' location. The authors referred to virtual teams, which are fundamentally technology-dependent, relying on the Internet, email communication, video conferencing, and audio connections for their activities. In this case, it can be highlighted that the digital tools enable seamless coordination and collaboration, allowing teams to function effectively across geographical boundaries.

However, even as various software technologies and media applications have matured and gained wider adoption, new technologies and software platforms are being introduced daily. New digital technologies have been developed for a wide range of industries, including customer relationship management, project management, sales management, and social media marketing applications (Anders, 2016). Thus, considering the need to test the influence of digitalization-specific tools on the management coordinating function, we propose the following hypothesis:

Hypothesis 3. (H3): *The use of specific digitization tools influences the exercise of the management coordinating function.*

Motivating function

The management motivating function focuses on motivating employees to maximize their contributions and achieve organizational goals. Therefore, motivating becomes an essential method by which employee efforts are cultivated and supported (Burduș & Popa, 2018).

Several studies (Cejthamr, 2020; Haris et al., 2023; Kurniasih et al., 2022; Lauby, 2014; Troshina & Mantulenko, 2020) have analyzed motivation in the digital technology context. As related to this subject, several aspects can be highlighted. First, according to Lauby (2014) and Kurniasih et al. (2022), familiarity with the technological context is crucial. Second, existing digital technologies can effectively promote employee engagement.

Employee engagement, communication, and motivation are supported by an optimal selection of technological tools. Sometimes it is better to use those tools and processes with which the employees are already familiar. For instance, using own online platforms and social groups can facilitate collaboration between members of the same team and also between employees in different divisions or offices. Another example refers to online educational resources, which offer the ability to access training materials and courses flexibly, regardless the location and time (Bussler & Davis, 2002). Furthermore, interactivity and instant feedback are becoming essential elements in modern organizations that facilitate the exchange of ideas and contribute to a dynamic learning process (Hershatter & Epstein, 2010). Considering the above, we propose the following hypothesis:

Hypothesis 4. (H4): *The use of digitalization-specific tools influences the exercise of the management motivating function.*

Controlling function

The final management function is the controlling function. Several studies (Banciu et al., 2023; Bell et al., 2014; Dewett & Jones, 2001) have analyzed the relationship between technological tools and organizational evaluation processes. An efficient evaluation process is based on collecting, storing, and analyzing relevant data and real-time information (Banciu et al., 2023). Real-time information has the advantage of providing managers with continuous insights into an organization's performance. This, in fact, will facilitate future informed decisions and quick adjustments when necessary.

What is more, digitization in the assessment process eliminates redundancies, and allows managers to focus on analyzing and interpreting data. For instance, nowadays, constant monitoring of key performance indicators (KPIs) is possible using digital tools (Lanzolla et al., 2020). The digitization can also create an optimal channel for communication between managers and employees during the assessment process (Yuan & Kim, 2015).

Any digitized assessment process assumes a mandatory adherence to privacy standards. This approach implies compliance with specific data protection regulations, rules, and directives developed to guarantee individual rights and prevent possible privacy abuse or violations (Al-Ruithe et al., 2018).

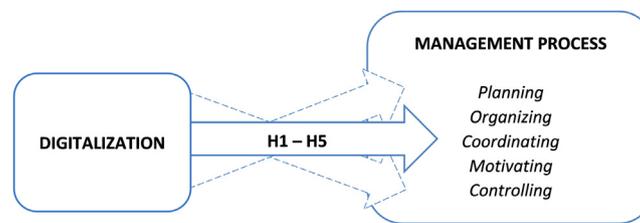


Fig. 1. Research framework. Source: Authors' design

According to Miceli et al. (2021), another important dimension in the evolution of digital assessment is process flexibility. It may be also approached as adaptability as digitization enables more dynamic and adaptable strategies to changes and evolving market demands. It may be also seen as adjustment, in the sense that by using digital technologies, organizations can quickly and efficiently adjust assessment protocols and methodologies to respond to changes in the business environment.

Considering the above, we propose the following hypothesis:

Hypothesis 5. (H5): *The use of digitalization-specific tools influences the exercise of the controlling management function.*

Materials and methods

Research framework

The purpose of this study was to identify possibilities for improving the management process of Romanian public institutions by integrating the opportunities digitalization can offer. To achieve this goal, the research adopted a confirmatory-first mixed mode approach (Sharma et al., 2024). In the confirmatory step, well-defined and theory-based research hypotheses related to the effects of digitalization on the management process were tested by means of PLS-SEM and, subsequently, in the exploratory step, was attempted to enhance the existing theory, by identifying specific data-driven segments with better explanatory power than the whole sample, by means of prediction-orientated segmentation procedure.

Considering the above hypotheses and that the five management functions are not interdependent, and their effective use implies the management process, the research framework can be described as shown in Fig. 1. Moreover, considering that digitalization could have different effects on the management process depending on various individual, organizational, and extra-organizational conditions, which are mostly not investigated, the research framework also considers possible unobserved heterogeneity concerning digitalization–management process relationships.

Research population and data collection

A questionnaire designed for a larger project aimed at investigating the integration of digitalization opportunities to improve the management process of Romanian public institutions was sent to public institution employees in Romania. The only inclusion criterion was employment status in a Romanian public sector organization, as only these employees can fully perceive the effects of the integration of digitization opportunities on management processes. No other inclusion or exclusion criteria were applied. Therefore, this study targeted employees from all development regions of Romania, regardless of the field of activity, size of the organization in which they work, or any other employee characteristics.

Data were collected as part of a questionnaire-based survey using an online form (Google Forms) available from July to September 2023. Respondents were informed about the purpose of the research and that it was part of a study for which the quality depends on

serious answers being provided. They were also informed about several aspects referring to their participation in the survey. They were told the participation was optional and that the resulting data were anonymous and used only for the stated purpose. They were given an estimation of the time they would need to complete the questionnaire. Furthermore, the participants were asked to provide their consent to take part in the survey.

For sampling and data collection, the "snowball" technique was chosen (Goodman, 1961), a non-probability sampling technique used in research to identify and select participants who are, in turn, able to provide information or participate in the study. This sampling technique was chosen because of the relatively limited time in which the data required for statistical processing needed to be obtained, large number of areas in which public administration institutions were present, and relatively limited number of contacts (potential participants) in these areas. Moreover, in the data collection, "Exponential Non-Discriminative Snowball Sampling" was applied, which represents a special variant of the "snowball" technique (Etikan et al., 2015). Thus, data collection began with the identification of a small number of participants from public institutions. After these participants were contacted and asked to complete the questionnaire, they were asked to recommend other eligible or relevant individuals for the study. Therefore, the network of participants from public institutions expanded permanently. After the questionnaire was distributed to participants and responses were removed from those who were not part of the research population or did not agree to participate in the study, 377 valid responses remained. The snowball sampling method was chosen because of its flexibility and because it makes it possible to interact with people who are difficult to reach and recruit to answer questions (Dragan & Isaic-Maniu, 2013; Parker et al., 2019). In our case, people working in public institutions are not easily convinced to participate in research, which requires an increase in the degree of confidence provided by the sampling method. However, this method has some disadvantages, including non-probability and not recruiting a random sample, which can lead to conclusions with a certain degree of bias (Sadler et al., 2010).

Measures

A structured questionnaire was used for data collection. The scales and items were analyzed using a Likert scale ranging from 1 to 5, which was adapted from previous studies or generated by the authors based on a theoretical approach to the analyzed concepts, as described below.

The use of digital tools (ISD) (Simion et al., 2023): This scale comprises several items that seek to analyze the extent of institutional use of digitization tools. The specific tools used include cloud-based data management software (Yadav et al., 2018), artificial intelligence (AI) and machine learning (ML) (Moran-Sanchez et al., 2021; Nissim & Simon, 2021), virtual reality (VR), augmented reality (AR), digital twins, blockchains (Juszczuk & Shahzad, 2022), automation solutions based on robots and/or drones (Sanchez-Uran Azana, 2021; Vanderhorst et al., 2021), business intelligence, geographic information systems (Hognogi et al., 2021), and 3D printing/3D streaming (Achille et al., 2019).

Management process/Management functions: This scale comprises five subscales that target five management functions: (1) *Planning function* (ENP) The five items of this scale aim to evaluate the extent to which public institutions elaborate and implement planning tools, such strategies, plans, and programs (Burdus & Popa, 2018; Deac et al., 2014). (2) *Organizing function* (SIT). The exercise of this function is evaluated by the existence of organizational activities such as the reorganization of positions and enrichment of these with new tasks (Burdus & Popa, 2018; Deac et al., 2014; Gabryelczyk, 2020). (3) *Coordinating function* (COM) was evaluated by five items describing different forms of communication, such as bi- and multilateral communication (Roberts & O'Reilly, 1974; Tkalac Verčić et al., 2021). (4) *Motivating function* (GSF). The seven items of this scale measure different forms of employee motivation. A sample item is "Feedback on work done" (Roberts & O'Reilly, 1974; Tkalac Verčić et al., 2021). (5) *Controlling function* (MPE). The items of this scale refer to the extent to which an organization's management uses performance measures, such as for tracking progress on meeting objectives and monitoring results (Bonner et al., 2002; Henri, 2006).

Data analysis

Structural equation modeling (PLS-SEM) was used to analyze the data collected using the questionnaire survey to determine the relationships among the research variables and test the proposed hypotheses. PLS-SEM was selected because it can estimate complex models that include several constructs, indicator variables, and structural paths, without imposing assumptions about data distribution. This represents a method which allows for a causal-predictive approach. The approach itself aims to identify future trends within statistical models. A specific case refers to attempting to test theoretical frameworks from a predictive perspective (Hair et al., 2019).

The model was built to identify the effects of integrating digitalization opportunities on improving management processes through five management functions: planning, organizing, coordinating, motivating, and controlling. After testing the research hypotheses, the results obtained via PLS-SEM were extended by using FIMIX-PLS segmentation, prediction-oriented segmentation (PLS-POS), and multigroup analysis (PLS-MGA). FIMIX-PLS and PLS-POS analyses were used to determine the degree of data heterogeneity (Haverila et al., 2024; Khatri et al., 2023). Following previous studies (Haverila et al., 2024; Khatri et al., 2023), statistical analysis was performed in three stages: (1) the first stage included data analysis by establishing construct validity and analyzing path coefficients using PLS-SEM; (2) the second step included FIMIX-PLS analysis, based on the assessment of unobserved heterogeneity in the relationships of the structural model, to determine the number of latent segments, and (3) the third step applied the PLS-POS procedure to estimate segment-specific models and characterize each segment according to the key variables analyzed. PLS-POS is an iterative process that aims to maximize the variance explained in the resulting segment solution. Moreover, the significance of the differences between path coefficients was analyzed using PLS-MGA multigroup analysis.

SmartPLS version 4 software was used for the combined use of PLS-SEM, PLS-POS, and PLS-MGA (Ringle et al., 2022).

Results

Sample structure

The final sample included 377 respondents, selected using a non-probabilistic sampling method based on the criterion of availability. The sample comprised 249 male (66.048 %) and 128 female respondents (33.952 %). Most respondents had >20 years of professional experience (33.952 %), followed by those with 16–20 years of experience (32.626 %). Furthermore, most respondents were part of an

organization with >500 employees (40.318 %) or from an organization that registered annual revenues between 10,000,000 and 49,999,999 euros (33.687 %). From the perspective of the field of activity, respondents can be grouped into five key fields: (1) other (36.605 % of respondents; this category includes fields such as internal affairs, finance, transport and infrastructure, justice, national defense, culture, foreign affairs, economy, entrepreneurship and tourism, health, agriculture and rural development, environment, water and forests, youth and equal opportunities, and other); (2) education (33.687 %); (3) research, innovation, and digitization (10.080 %); (4) European investments and projects (9.814 %); and (5) development, public works, and administration (9.814 % of respondents).

Model evaluation

PLS-SEM was used to develop an analysis model based on the relationships between digitalization-specific tools and management functions (planning, organizing, coordinating, motivating, and controlling) to test the effects of integrating digitalization opportunities on the improvement of management processes. According to the recommendations of (Hair et al., 2019), before testing the hypotheses, the reliability and convergent validity of the PLS-SEM were evaluated using the information in Table 1. The internal consistency of the six scales used in this study was evaluated using Cronbach's alpha coefficient, which ranged between 0.703 and 0.914 and exceeded the threshold value of 0.70 (Hair Jr. et al., 2020; Shmueli et al., 2019). The construct reliability was assessed using the coefficients rho_a and rho_c, which had values above the recommended limit of 0.70 (Hair Jr. et al., 2020; Shmueli et al., 2019). Convergent validity was analyzed using outer loadings and average variance extracted (AVE). Most external loadings exceeded the critical value of 0.708 (Hair Jr. et al., 2020; Shmueli et al., 2019), and all the AVE values were above the threshold value of 0.50 (Hair Jr. et al., 2020; Shmueli et al., 2019). These results provide sufficient evidence supporting the reliability and validity of the measurement model.

Regarding the discriminant validity of the measurement model, the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT) were used according to the values in Table 2. According to the Fornell–Larcker criterion, the "square root" of each latent variable's AVE was greater than all correlations between the latent variables (Chin, 1998; Hair et al., 2019). The HTMT ratios were below the threshold value of 0.90 (Hair et al., 2019; Hair Jr. et al., 2020). Considering these results, the PLS-SEM in this study can be considered to exhibit discriminant validity.

Effects of integrating digitalization opportunities in management process improvement

Before analyzing the effects of integrating digitalization opportunities on management process improvement, a PLS-SEM was designed from a structural perspective and evaluated. Therefore, collinearity between the predictors was evaluated using variance inflation factor (VIF) values below the threshold value of 5 (Hair Jr. et al., 2017), and no collinearity problems were identified. The results of the structural model are shown in Fig. 2.

The coefficients of determination of the endogenous constructs (R^2) presented in Fig. 2 indicate that digitalization-specific tools explain 25.40 % ($R^2 = 0.254$) of the variance in the planning function, 17.30 % ($R^2 = 0.173$) in the organizing function, 8.20 % ($R^2 = 0.082$) in the coordinating function, 7.90 % ($R^2 = 0.079$) in the motivating function, and 23.00 % ($R^2 = 0.230$) in the controlling function. The direct effects of digitalization-specific tools on the five management functions specific to the constructed research hypotheses are presented in Table 3.

Table 1
Assessing the reliability and convergent validity of the measurement model.

Latent construct	Indicator	External loads	Cronbach's Alpha	rho_a	rho_c	AVE
Use of digital tools (ISD)	ISD1	0.688	0.912	0.916	0.927	0.559
	ISD2	0.740				
	ISD5	0.651				
	ISD6	0.790				
	ISD8	0.790				
	ISD11	0.794				
	ISD14	0.807				
	ISD15	0.728				
	ISD16	0.698				
	ISD17	0.773				
Planning function (ENP)	ENP 1	0.738	0.719	0.736	0.817	0.528
	ENP 2	0.670				
	ENP 3	0.779				
	ENP 5	0.715				
Organizing function (SIT)	SIT 1	0.891	0.914	0.949	0.933	0.703
	SIT 2	0.885				
	SIT 3	0.909				
	SIT 4	0.710				
	SIT 5	0.685				
	SIT 6	0.917				
Coordinating function (COM)	COM 3	0.843	0.703	0.748	0.828	0.618
	COM 4	0.704				
	COM 5	0.804				
Motivating Function (GSF)	GSF 1	0.661	0.895	0.954	0.908	0.587
	GSF 2	0.680				
	GSF 3	0.732				
	GSF 4	0.815				
	GSF 5	0.843				
	GSF 6	0.749				
	GSF 7	0.861				
Controlling Function (MPE)	MPE 1	0.821	0.724	0.756	0.842	0.642
	MPE 4	0.861				
	MPE 5	0.713				

Note(s): rho_a and rho_c - Composite reliability; AVE – Average variance extracted.
Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

Table 2
Discriminant validity assessment.

Latent construct	Fornell–Larcker criterion						HTMT					
	COM	ENP	GSF	ISD	MPE	SIT	COM	ENP	GSF	ISD	MPE	SIT
COM	0.786											
ENP	0.438	0.727					0.625					
GSF	0.344	0.413	0.766				0.436	0.494				
ISD	0.287	0.504	0.281	0.748			0.334	0.563	0.250			
MPE	0.286	0.449	0.374	0.480	0.801		0.409	0.595	0.412	0.574		
SIT	0.191	0.429	0.193	0.416	0.336	0.838	0.246	0.468	0.196	0.431	0.402	

Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

An analysis of the values presented in Table 3 shows that the use of digital tools (ISD) has a positive effect on all five functions of management processes: planning (ENP) ($\beta = 0.504$; $p < 0.001$), organization (SIT) ($\beta = 0.416$; $p < 0.001$), coordinating (COM) ($\beta = 0.287$; $p < 0.001$), motivating (GSF) ($\beta = 0.281$; $p < 0.001$), and controlling (MPE) ($\beta = 0.480$; $p < 0.001$). Thus, H1–H5 are supported.

Identifying unobserved heterogeneity via the FIMIX-PLS and PLS-POS procedures

After testing the research hypotheses regarding the relationship between digitization (ISD) and functional exercise, prediction-oriented segmentation (PLS-POS) and multigroup analysis (PLS-MGA) were used to account for unobserved heterogeneity in PLS-SEM. The FIMIX-PLS procedure used to identify the number of segments is presented in Table A1, with three specific segments determined for the analysis.

The results in Table A2 show that the weighted average R² values of each analyzed construct were greater than the original dataset's R² values. Therefore, according to the mean-weighted R² criterion, the three-segment solution fit the data better than the assumption of homogeneity.

After determining the number of segments to be three, a multi-group analysis (Cheah et al., 2023) was performed to identify whether differences were present among each pair of the three segments in terms of the direct relationships between digitization-specific tools and the five management functions. Table 4 presents the results.

Analyzing the data in Table 4 indicates that, with one exception, the direct effects of ISD on the five management functions were significantly different between Segments 1 and 2. However, fewer direct effects were differed between Segments 2 and 3, respectively 1 and 3. These results support the existence of different effects of ISD on the exercise of management functions at the level of each segment.

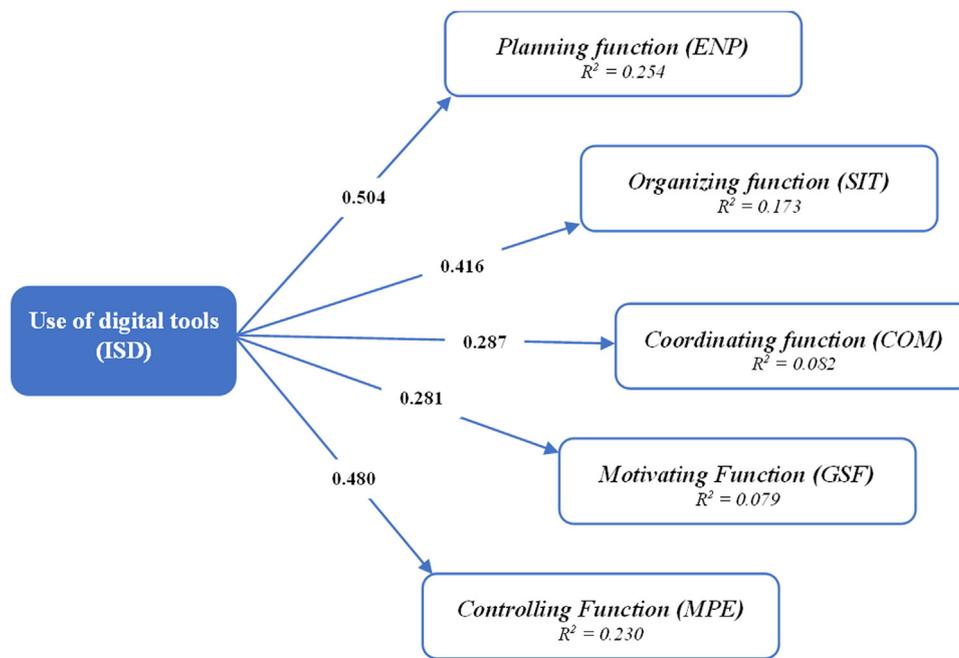


Fig. 2. The structural model. Source: Authors' design using SmartPLS 4 (Ringle et al., 2022).

Table 3
Direct effects of specific digitization tools on management functions.

Hypothesis	Relationship	Beta	Std. Dev.	T statistic	BCCI	Decision
H1	ISD → ENP	0.504	0.042	12.066***	0.425; 0.565	Supported
H2	ISD → SIT	0.416	0.041	10.151***	0.337; 0.476	Supported
H3	ISD → COM	0.287	0.049	5.900***	0.197; 0.358	Supported
H4	ISD → GSF	0.281	0.044	6.363***	0.205; 0.345	Supported
H5	ISD → MPE	0.480	0.045	10.703***	0.396; 0.546	Supported

Note(s): *** $p < 0.001$; BCCI, bias-corrected confidence interval. Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

Table 4
Multigroup analysis.

Relations	β_{s1}	β_{s2}	β_{s3}	$\Delta\beta_{(s1-s2)}$	$\Delta\beta_{(s1-s3)}$	$\Delta\beta_{(s2-s3)}$
ISD → ENP	0.724***	-0.494***	0.640***	1.218***	0.084	-1.133***
ISD → SIT	0.517***	0.220	0.606***	0.297*	-0.089	-0.386**
ISD → COM	0.479***	-0.558***	0.662***	1.037***	-0.184*	-1.221***
ISD → GSF	0.739***	-0.545***	-0.449	1.284***	1.188***	-0.096
ISD → MPE	0.648***	0.264	0.552***	0.384	0.096	-0.288

Note(s): *** $p < 0.001$; ** $p < 0.01$; and * $p < 0.05$. Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

Discussion

Segment characteristics

Analyzing the information in Table A3, Segment 1 includes the most observations (205) and is characterized by the highest use of digitization-specific tools ($M = 3.509$; $SD = 0.673$), predominantly exercising the controlling, motivating, and coordinating managerial functions. Segment 2 is next from the perspective of using digitalization-specific tools ($M = 3.129$; $SD = 0.688$); it includes 104 cases and is characterized, among all segments, by the most intensive use of the functions of planning and organizing. Segment 3 contains 68 cases and is characterized by lower use of specific digitization tools than the other two segments ($M = 3.122$; $SD = 0.927$) and by exercising the five management functions with the lowest intensity compared to Segments 1 and 2.

From the perspective of demographic variables (Table A4), Segment 1 has the highest percentage of male respondents and the lowest percentage of female respondents, with >15 years of experience in their organization who predominantly come from organizations in education, and from organizations with annual revenues of >10,000,001 euros. Segment 2 includes predominantly male respondents with >15 years of experience in their organization who worked mostly in organizations classified under "other fields," with annual incomes between 1000,001 and 10,000,000 euros. Segment 3 is characterized by a higher percentage of male respondents with >15 years of experience in their organization, who work predominantly in an organization classified under "other fields" and have annual incomes between 1000,001 and 10,000,000 euros.

Moreover, the ANOVA results presented in Table 3 indicate statistically significant differences between the three segments, both in terms of the use of digitization-specific tools and the exercise of

planning, motivating, and controlling functions. Likewise, all analyzed demographic variables are statistically associated with three-segment membership (Table 4), thereby providing supplementary validation and supporting the managerial usefulness of the prediction-orientated segmentation approach (Bénet et al., 2022).

Effects of digitalization on the managerial process

The digital transformation era comes with challenges brought by uncertainty and it represents a crucial element for strategic information systems (Nyagadza, 2022). The society has experienced the massive adoption of technological solutions such as cloud computing, the use of virtual agents, and electronic payments. Researchers believe that investments in digital technologies will trigger opportunities which will eventually lead to the improvement of the value-creation process (Fähndrich, 2023). At the same time, these modern technologies will quickly identify difficulties and will generate effective responses to them, supporting efficient and accurate decision making. Other related effects will be felt as reducing the time needed to solve problems, or offering the possibility of new communication channels, and also encouraging citizens' active involvement (Szymaniec-Mlicka, 2023).

There are strong believes that in order to keep up with this phenomena, governments must understand at first its significance and then define their strategic perspective, while identifying necessary information regarding the state of digitalization that allows for comparative analysis and exchange of best practices (Frach et al., 2017). Our research aimed to identify the extent to which the use of digital tools within public-sector institutions influences management functions. While noting that the effects of using digital tools are all positive and significant, we will further emphasize the importance of using them for managerial functions in public institutions, referring to planning, organization, coordination, motivation, and control. The results confirm the veracity of the formulated hypotheses, supporting the influence of using digitalization-specific tools on managerial functions in public institutions.

Effects on the exercise of the planning function

Digitalization-specific tools (ISD) positively, significantly, and strongly influence the exercise of the management planning functions (ENP). These results show that the more tools specific to digitization that are used at the level of a public institution, such as artificial intelligence, machine learning, blockchain-type tools, and automation solutions based on robots and/or drones, the more the predictive elements at the level of the respective institution are influenced; more precisely, this includes the elaboration and implementation of forecasts, strategies, policies, and programs. These results reinforce the findings of other studies (ElMadany et al., 2021) showing that in a digital context, the use of advanced analysis tools and expertise in emerging technologies facilitates the achievement of effective forecasts at the organizational level and supports more accurate forecasts regarding market trends and changes in the industry or customer behavior.

In particular, the results obtained were similar for Segments 1 and 3; however, for Segment 2, the specific instruments of digitization negatively and significantly influenced the exercise of the planning function.

Effects on the exercise of the organizing function

By analyzing the effects of the integration of digitalization opportunities on improving the organizing function of management (SIT), we found that tools specific to digitalization positively, significantly, and strongly influence this function. Thus, it can be emphasized that integrating digitalization-specific tools in the activities of public institutions leads to changes at the level of the management organizing function, including the disappearance of some positions and/or

dismissal of the occupants of some positions as a result of digitalization, elimination and/or reduction of some tasks in the position structure by taking them over with digital elements, greater use of telework, amplification of flexibility at the institutional level, and reduction in the number of hierarchical levels in an institution. Therefore, an organization's management function is closely related to the efficient allocation and coordination of its resources to achieve its objectives (Burduș & Popa, 2018). The effects of digital tool integration on the exercise of organizational function have also been examined in other studies. For example, digitization can lead to the automation of operational processes, thereby improving resource allocation and management (Matt et al., 2015). Through integrating digital platforms, the ways in which members of an organization interact and facilitate the effective coordination of activities are reconfigured (Henderikx & Stoffers, 2022). Another effect of digital integration refers to supporting the effective management of personnel in organizations according to Kambur and Yildirim (2023). The same study shows that the integration of digitalization-specific tools influences the operation of managerial functions, amplifying also the flexibility at the institutional level. Therefore, these results reinforce previous findings (Miceli et al., 2021) showing that digitization allows for the adoption of more dynamic and adaptable approaches to organizational changes or evolving market requirements, thus ensuring process flexibility. Moreover, the findings indicate that digitization integration leads to the elimination and/or reduction of some tasks from the job structure by taking them over with elements of a digital nature, which is in line with the results of another study (Kuusisto, 2017), highlighting that digitization makes information more accessible and transparent and can lead to the automation of previously manual tasks.

The analysis at the level of the three segments illustrated that ISD instruments positively and statistically significantly influence the exercise of organizational function at the level of Segments 1 and 3 and non-significantly at the level of Segment 2.

Effects on the exercise of coordinating function

Digitalization-specific tools have been proven to positively and significantly influence the management coordinating function (COM). These results indicate that the use of digitalization-specific tools in processes at the level of public institutions in Romania influences the coordination of management processes and use of forms of communication such as nonverbal communication, bilateral communication between manager and subordinate, or multilateral communication between manager and several subordinates. As noted above, communication is the essence of the coordinating function and is thus a vital element in organizations for facilitating information exchange, aligning common goals, and increasing team effectiveness and cohesion (Burduș & Popa, 2018). These results are similar to those of other studies (Patruti-Baltes, 2016) showing that digitization allows for a dynamic transformation of business communication in organizations and facilitates the inclusion of additional communication channels. Furthermore, Daim et al. (2012) showed that digital platforms significantly improve communication and collaboration, thereby facilitating rapid and efficient interactions among organizational members. Similarly, Kuusisto (2017) noted that many information technologies directly affect communication within organizations.

Although all the effects of ISD on the exercise of the coordinating function were statistically significant at the level of the three segments analyzed, they were positive only for Segments 1 and 3 and negative for Segment 2.

Effects of exercise on motivating function

Digitalization-specific tools can positively and significantly influence the exercise of the management motivating function (GSF) at the lowest intensity. In this sense, we found that the use of tools

specific to digitization has positive effects on the motivation of employees of public institutions, increasing their degree of satisfaction with the availability of the hierarchical superior in the process of communicating with that superior information regarding the problems they encounter. The degree to which the hierarchical superior understands the problems they encounter, extent to which communication at the organizational level helps them feel part of the respective institution, extent to which communication within the institution contributes to the achievement of its objectives regarding feedback on the work done and their own contribution to the organization's success. These results support the specificity of the motivating function that focuses on encouraging employees to achieve the organization's goals and becomes an essential method to cultivate and support employee motivation (Burduș & Popa, 2018). Similarly, Bolli and Pusterla (2022) found a positive association between digitization and job satisfaction and that easier interaction with colleagues and superiors, facilitated by digitization, is positively associated with job satisfaction. Al-kharabsheh et al. (2023) highlighted that the use of digital tools in HR practices (e.g., digital training) has significant effects on employee motivation.

The results obtained for the three analyzed segments illustrate that digitalization-specific tools have positive and significant effects on the motivating function only at the level of Segment 1; however, at the level of Segment 2, the effects are still significant but negative, while at the level of Segment 3, these effects are negative and insignificant.

Effects on the exercise of the controlling function

Digitalization-specific tools showed positive and statistically significant effects on the exercise of the controlling function. Therefore, the use of more intense digitalization-specific tools has a positive influence on the control of management processes in public institutions, contributing to the increase in the extent to which institutional management uses performance measurements to follow towards achieving objectives and adopts corrective measures, or ensures the continuity of the control of the activities performed. These results show that through the possibility of collecting, storing, and analyzing data, as facilitated by digitization, the efficiency of the evaluation process at the organizational level can also improve (Banciu et al., 2023). Furthermore, these results support the findings of other studies showing that the integration of digital tools into various activities facilitates the monitoring of KPIs in organizations (Lanzolla et al., 2020) and effective feedback and communication, thus providing an optimal framework for dialog between managers and employees during the evaluation process (Yuan & Kim, 2015). Moreover, the results of this study indicate that the use of tools specific to digitization influences the exercise of the controlling function and, by that, facilitates the continuity of the control of the activities carried out, thus strengthening the results of another study (Fähndrich, 2023), which shows that digitization and the use of new technologies affect the control function of management and can contribute to the more efficient and detailed performance of control tasks at the organizational level.

Regarding the effects of digitalization-specific tools on the exercise of the controlling function at the level of Segment 3, these effects are positive at the level of all segments but statistically significant only at the levels of Segments 1 and 3.

Conclusions

Main conclusions

This study aimed to identify the effects of integrating digitalization-specific tools on management processes and planning, organizing, coordinating, motivating, and controlling management functions. To achieve this goal, a questionnaire-based survey was

designed and used to collect responses from 377 employees of public institutions. To analyze the data, a PLS-SEM was built that highlighted the direct effects between the variables investigated in the present study and tested the research hypotheses.

The main results indicate that integrating digitalization-specific tools has positive and significant effects on all five management function processes: planning, organization, coordinating, motivating, and controlling. Moreover, the results were extended using FEMIX-PLS, PLS-POS, and multigroup analysis (PLS-MGA). FEMIX-PLS analysis allowed the identification of the three segments analyzed in this study. The main findings show statistically significant differences between the three segments regarding the use of digitalization-specific tools and the exercise of the functions of planning, motivating, and controlling.

Theoretical and managerial implications

These results demonstrate the utility of the proposed approach from the theoretical, methodological, and practical perspectives. Therefore, from a *theoretical perspective*, the results of this study reinforce the theoretical approaches and findings of other studies and can be useful for management theorists wanting to study the links between digitalization-specific tools and the exercise of functions specific to management processes. Moreover, although previous studies have argued for the importance of digitalization for better planning and more efficient organization of tasks, no research has previously addressed digitalization–management process links in an integrated matter. In contrast, on the premise that digitalization could have different effects on the management process depending on numerous individual, organizational, and extra-organizational conditions, adopting a confirmatory-first mixed mode approach (Sharma et al., 2024), the proposed research framework also considers possible unobserved heterogeneity concerning the digitalization–management process relationships, and its results outlined specific instances. Furthermore, while previous studies focused mostly on digitalization–management process links in the business context, to our knowledge, the present study is the first to concentrate on the public environment.

From a *practical and managerial perspective*, the results of this study may be of interest to decision-makers in public administration organizations because they show the effects of digital tools on the exercise of each management function, thus allowing decision-makers to improve the relationships between these variables at the level of the institution in which they are involved. Moreover, the distinct presentation of these results for each of the three segments characterized by different particularities allows decision-makers to identify the situations in which their institution falls in priority. Nevertheless, although the digitization process generally improves the functioning of the management process, this study's findings suggest the existence of situations in which the effects can be negative, especially in the planning, communicating, and motivating functions, when the use of digital tools is not considered a priority (Segment 2).

Likewise, the results are important at the organizational level, as previously highlighted, in relation to the management of public institutions and support provided to make decisions regarding increasing the degree of digitization of institutions and correlating the exercise of management functions with the digital tools used. The results are also important at the individual level, as each manager exercises these management functions in relation to their own work tasks, as well as the use of digital tools to fulfill them.

From a *methodological perspective*, following a confirmatory-first mixed mode approach (Sharma et al., 2024), combined PLS-SEM analysis with PLS-POS and multigroup analysis (PLS-MGA) allows us to increase the usefulness of the theoretical and practical results obtained through this research by generating additional insights for specific groups.

Research limitations and future directions

The main limitation of this research is that the investigation was carried out only in the Romanian context, and only the particularities of the activities specific to the public environment of public institutions were captured, which does not allow for the generalization of the results obtained. In the future, similar studies should be conducted in different national and organizational contexts to validate the results obtained and capture possible context-specific insights.

Other limitations of the research may result from the possible reticence of public employee respondents to provide objective answers to the questionnaire as well as the complexity of the information presented in the questionnaire, which assumed a minimal knowledge base regarding current digital tools. To mitigate these effects, the relationships may be further investigated and nuanced using qualitative research methods, such as focus groups or interviews with key stakeholders.

CRedit authorship contribution statement

Ion Popa: Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Simona Cătălina Ștefan:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ana Alexandra Olariu:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Ștefan Cătălin Popa:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis.

Declaration of competing interest

Authors declare no competing interests

CRedit authorship contribution statement

Ion Popa: Writing – review & editing, Validation, Supervision, Project administration, Methodology, Formal analysis, Conceptualization. **Simona Cătălina Ștefan:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ana Alexandra Olariu:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Ștefan Cătălin Popa:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis.

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Appendix

Tables A1, A2, A3, A4

Table A1

FIMIX-PLS analysis to identify the number of segments.

	Partitions with 1 to 4 segments			
	1 Segment	2 Segments	3 Segments	4 Segments
Segment 1	100.000 %	70.900 %	48.600 %	44.000 %
Segment 2		29.100 %	28.600 %	30.700 %
Segment 3			22.800 %	14.800 %
Segment 4				10.400 %
Model selection criteria				
AIC	5038.788	4829.026	4720.496	4691.66
AIC3	5048.788	4850.026	4752.496	4734.66
AIC4	5058.788	4871.026	4784.496	4777.66
BIC	5078.137	4911.659	4846.412	4860.861
CAIC	5088.137	4932.659	4878.412	4903.861
HQ	5054.405	4861.822	4770.47	4758.813
MDL5	5315.533	5410.19	5606.079	5881.663
LnL	-2509.394	-2393.51	-2328.25	-2302.83
EN	0.000	0.624	0.561	0.567
NFI	0.000	0.698	0.585	0.567
NEC	0.000	142.296	165.854	163.549
Weighted average R²				
ENP	0.254	0.266	0.353	0.333
SIT	0.173	0.180	0.206	0.217
COM	0.082	0.073	0.183	0.172
GSF	0.079	0.192	0.308	0.363
MPE	0.230	0.276	0.336	0.349
Mean	0.818	0.987	1.386	1.434

Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

Table A2

Coefficients of determination for the three-segment solution.

Construct	R ² original	Weighted mean R ²	R ² S1	R ² S2	R ² S3
ENP	0.254	0.426	0.524	0.244	0.409
SIT	0.173	0.225	0.267	0.048	0.368
COM	0.082	0.290	0.229	0.312	0.439
GSF	0.079	0.416	0.546	0.297	0.201
MPE	0.230	0.303	0.420	0.070	0.305

Source: Authors' calculations using SmartPLS 4 (Ringle et al., 2022).

Table A3

Characterizing the segments in terms of using digital tools and exercising management functions.

Construct	Segment 1 (N = 205)		Segment 2 (N = 104)		Segment 3 (N = 68)		ANOVA
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
ENP	3.637	0.675	3.675	0.568	3.261	1.149	7.439***
SIT	2.959	1.090	3.118	0.996	2.872	1.145	1.228
COM	3.920	0.535	3.798	0.623	3.738	0.795	2.810
GSF	4.165	0.508	3.916	0.543	3.158	1.003	64.264***
MPE	4.197	0.506	4.193	0.465	3.610	0.950	26.479***
ISD	3.509	0.673	3.129	0.688	3.122	0.927	12.922***

Note(s): N - number of cases; *** - p < 0.001.

Source: Authors' calculations using SPSS.

Table A4

Characterizing the segments in terms of demographic variables.

Demographic variables	Segment 1 (N = 205)	Segment 2 (N = 104)	Segment 3 (N = 68)	χ ²
	Gender			
Female	26.341 %	41.346 %	45.588 %	11.936**
Male	73.659 %	58.654 %	54.412 %	
Seniority				
<10 years	17.561 %	19.231 %	22.059 %	11.829*
11–15 years	11.220 %	13.462 %	26.471 %	
Over 15 years	71.220 %	67.308 %	51.471 %	
Under 1000,000 €	7.317 %	9.615 %	10.294 %	13.437**

(continued)

Table A4 (Continued)

	Demographic variables	Segment 1 (N = 205)	Segment 2 (N = 104)	Segment 3 (N = 68)	χ^2
Organization annual revenue	Between 1000,001 and 10,000,000 €	40.976 %	46.154 %	63.235 %	
	Over 10,000,0001 €	51.707 %	44.231 %	26.471 %	
Field of activity	Education	40.976 %	27.885 %	20.588 %	21.940*
	Research, innovation and digitalization	9.268 %	7.692 %	16.176 %	
	European investments and projects	7.805 %	15.385 %	7.353 %	
	Public works development and administration	10.244 %	5.769 %	14.706 %	
	Other	31.707 %	43.269 %	41.176 %	

Note(s): N - number of cases; χ^2 - chi-square test; ** - $p < 0.01$; * - $p < 0.05$.

Source: Authors' calculations using SPSS.

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