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E-governance and AI impact on the improvement of e-government services: transformative leadership as a mediator

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Abstract: The study examines the role of AI tools and e-governance in enhancing public sector services in Jordan, emphasising transformational leadership in integrating these technologies. A quantitative descriptive exploratory approach was used, as AI application in Jordan's public sector remains underexplored. This approach facilitated comprehensive data collection through surveys and interviews. Data analysis employed structural equation modelling (SEM) via smart partial least squares V4.1 and SPSS V26. Findings indicate that transformational leadership is a key driver of improved e-government services, with leaders who inspire change being essential for successful implementation. Transparency and accountability also enhance service effectiveness. However, AI technologies like neural networks and genetic algorithms had limited impact. The study recommends further exploration of advanced AI techniques to improve government services and suggests investigating the evolution of transformational leadership over time to better understand its mediating role in service delivery.

Keywords: e-governance; AI; E-government services transformative leadership; SEM; structural equation modelling; PLS; partial least squares.

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1 Introduction

As the technological era progressed, it introduced a growing array of new challenges and uncertainties. In response, practitioners began to concentrate on more specific areas of action, and researchers narrowed their focus to particular subjects of study (Mensah, 2019). Those examining the intersection of information and communication technologies (ICTs) and the public sector initiated research streams that explored topics such as the

impact of technology on government organisation, performance, and bureaucratic reform (e.g., Kraemer and King, 1986, 2003), workplace effects and implications for the public ICT workforce (e.g., Perry and Kraemer, 1993), and specific policy concerns like personal privacy (e.g., Reagan, 1986) and access to government information (e.g., Relyea, 1986).

In practice, e-government or digital government has largely focused on utilitarian applications, driven by technology-centered initiatives aimed at enhancing services, administration, or management. As Nawafleh and Khasawneh (2024) notes, the majority of research in this area has also been utilitarian, primarily addressing practical issues of efficiency and functionality, while paying less attention to deeper evaluative questions about governance, such as the role and purpose of the state or the rights and preferences of citizens. In a historical review, Nawafleh (2020) identified five key objectives of e-government, finding that most efforts have concentrated on online services and improved management. In contrast, policy support has seen only modest progress, and there has been minimal advancement in areas like enhanced democracy or institutional reform. Similarly, Grönlund and Andersson (2007) argue that while e-government research is expanding in volume and improving in methodological rigour, it still falls short in addressing complex, fundamental questions of governance.

E-government initiatives have primarily served as extensions of the existing managerialism governance paradigm, with their implementation largely focusing on the providers' perspectives (Nawafleh, 2018a, Márcia Barbosa et al., 2013; Osman et al., 2014; Van Velsen et al., 2009). As a result, despite their recognised advantages, the impact of these initiatives has been limited. Expanding the scope of technology applications in government to include interactions with citizens – an aim of e-governance – can better address citizens' needs and desires. However, while various studies (Anttiroiko, 2012, Nawafleh, 2022, Baxter, 2017; Fung, 2015; Janssen and van der Voort, 2016; Manoharan et al., 2017; Marche and McNiven, 2009; Osborne, 2006; Peters, 2010; United Nations, 2008; Wang et al., 2019) have identified the needs and characteristics of this new governance model, there has been little work on providing specific guidelines for its implementation. It is essential to develop research focused on actionable subjects that can facilitate practical advancements in this area.

Studies have explored the application of AI algorithms to analyse public opinion and sentiment regarding policies and government initiatives. For instance, Bostrom et al. (2022) used natural language processing techniques to examine social media data and evaluate public sentiment towards political parties. Their findings underscored the potential of AI in gauging public perception and its implications for policymaking (Arora et al., 2024).

E-government leaders who implement projects across various sectors and levels are true pioneers. They confront the significant challenges of e-government and take professional risks as they apply their skills in cross-boundary leadership (Nawafleh, 2021). Through their experiences, they develop a set of promising practices and policies for future generations of e-government leaders (CP and Susanto, 2019). To succeed, they must remain focused on their organisation's mission and goals, effectively manage the attitudes and commitments of senior leaders within their organisations, and present concrete evidence of the impact of intergovernmental activities and projects.

This evidence must be communicated clearly, swiftly, and compellingly to justify participation beyond the confines of their individual organisations (Kumajas, 2021).

At the heart of ‘Digital Economy Transformation’ lies the principle of effective e-government leadership, as achieving transformation necessitates mobilising those with the power to define the government’s role (Swedberg and Douglas, 2003). Irani et al. (2006) argue that government leaders should exercise particular caution during the Transaction Stage, as it represents the first significant challenge in ensuring successful e-government implementation. Additionally, organisational innovation and change are complex phenomena that are not yet fully understood within the context of governmental growth. Research into the transformation of enterprises or government agencies must not only deepen understanding of fundamental change but also develop the methods and tools necessary to facilitate that change. It is essential to adopt multiple perspectives on the challenges of change – what drives it, what enables it, and what factors can either facilitate or hinder its success (Al-Ajlouni et al., 2024; Rouse and Baba, 2006).

The significance of this study lies not only in its current knowledge but also in its practical implications, as it offers a conceptual framework for decision-makers and public policy makers in Jordan. This plays a crucial role in the successful implementation of AI technologies and e-governance in Jordan. Beyond that, the importance of this study lies in its unique and distinctive perspective for developing countries, where such topics are relatively new in terms of infrastructure and AI technologies. It is hoped that the findings of this study will contribute to guiding strategies for adopting AI and e-governance technologies in similar contexts in Arab countries and other developing nations.

On the other hand, the importance of using the transformational leadership style in this study lies in its close alignment with the goals of integrating advanced technologies like AI, e-governance, and other emerging technologies in developing countries. Transformational leadership focuses on inspiration, visionary thinking, and the ability to drive change, making it an ideal style for environments seeking transformation, such as the public sector in Jordan and similar developing countries. Transformational leaders are known for their ability to create future-oriented visions, such as AI, and more importantly, their ability to inspire employees to transcend personal interests in favour of the greater good. Additionally, transformational leadership encourages change, making it particularly effective for managing change efforts within the public sector.

2 Formulation of study hypotheses and theoretical framework

E-governance, or electronic governance, involves the use of ICT to deliver government services and facilitate communication and information exchange between the government and its four key stakeholders: citizens, businesses, government employees, and other government agencies (Grigalashvili, 2023).

There is no universally accepted definition of governance methods. While some focus on citizen-centered sovereignty, others emphasise decentralisation and citizen engagement to enhance government transparency, accountability, and participatory governance. Regardless of the approach, it is evident that smart governance relies on e-governance, which employs innovative and transparent networks using modern tools like mobile applications (Gjaltema et al., 2020). This ensures the effective and efficient

implementation of policies, with active involvement and oversight by key societal actors. E-governance aims to institutionalise public participation in decision-making through two-way, accessible communication channels (Davies, 2015). However, technology alone does not create e-governance; its effectiveness depends on the institutions using it. Meaningfully transforming urban environments through technology requires rethinking the approach to e-governance, therefore smart-society infrastructures are ineffective without smart governance (Abuljadail et al., 2023). Governance refers to how organisations or nations are managed at the highest level through systems, while the government is a group of people formally responsible for running a country. Therefore, those in charge of managing the country must apply top-level management practices and systems, which require smart-society infrastructure (Hartanto et al., 2021). This infrastructure focuses on creating new forms of social organisation, such as e-government, e-governance, and telecommunication services, to facilitate mediated communication, citizen engagement in decision-making, and remote services (Umbach and Tkalec, 2022).

E-government, or electronic government, refers to the use of digital technologies and online platforms to provide government services, facilitate information exchange, and engage with citizens, businesses, and other stakeholders. It includes various internet-based initiatives designed to enhance the efficiency, accessibility, and transparency of government functions (Chávez-Chica et al., 2021).

E-government refers to a broad perspective, the primary goal is to use digital network technologies to increase citizen involvement in government (Nawafleh, 2018b). The widespread availability of computer networks creates opportunities for greater political participation and allows the state to transform into an open, interactive network, moving away from both traditional hierarchical bureaucracies and more recent market-based service delivery models like the new public management (Bayona-Oré and Morales Lozada, 2021). Advocates of this view argue that the extensive use of the internet should replace the older, inward-facing information systems of public bureaucracies, which have been in place since the 1960s, with outward-facing networks that blur the line between an organisation's internal information processing and its external users (Pariso and Marino, 2020).

Each generation of technological implementation has encountered new and complex challenges. In the early stages, the size, cost, and limited functionality of computers restricted their use to specific tasks. As computers became more affordable and versatile, managing the growing technology became a significant hurdle. Today, privacy and security concerns have gained prominence as technology increasingly permeates society, exposing new vulnerabilities that need to be addressed (Myeong and Bokhari, 2023).

Currently, the primary focus of government applications is improving efficiency through ICTs. This trend is expected to continue in the future, with recent efforts placing greater emphasis on democratic engagement (Kamolov and Konstantinova, 2017).

As new technologies emerge, rules and policies must be developed or adapted, adding complexity to their integration and sometimes reducing the benefits of adopting new systems]. Many government agencies have struggled to transition to digital data, while others, such as security and law enforcement organisations, grapple with controlling information flow, either through withholding data or collecting excessive amounts (Alshehri et al., 2021).

To discuss public e-services, particularly those provided by governmental organisations, it's important to first define what an e-service is. The term 'e-service' refers to an electronic service, meaning it is delivered electronically (Scupola et al., 2009). However, it's essential to clarify what constitutes a service and what it means for a service to be mediated electronically. This section will explore the meanings of the terms 'e-' and 'service', as well as the implications of their combination.

Electronic service, commonly referred to as e-service, is a broad term that encompasses services delivered through ICTs. The concept of e-service has diverse applications across various fields, with the two primary domains being e-business (or e-commerce) and e-government (or non-commerce) (Panayiotou and Stavrou, 2021). According to the (Computer Language Company, 2009) e-services serve as an umbrella term for services available on the internet. These include e-commerce transaction services for managing online orders, application hosting by application service providers (ASPs), and any processing capabilities accessible on the web.

Chun Hai (2007) posits that e-services enable online purchase and sale transactions, distinguishing them from traditional websites that primarily offer descriptive information. Similarly, Zeithaml and Bitner (2003) define e-service as web services delivered via the internet. (Wilson, 1998) describes an e-service as a series of activities that occur during the interaction between a provider and a customer through an electronic channel.

Taherdoost et al. (2014) summarise the characteristics of e-services as follows: intangibility, process nature, homogeneity, inseparability, non-ownership, interaction, self-service, and non-rivalry.

In a similar vein, the European Commission defines e-services as resources on the internet designed to enhance communication between citizens, businesses, and European Institutions. European Commission (2006) further defines an 'e-service' as one delivered over the internet (or a similar electronic network) that heavily relies on information technology for its provision. This definition emphasises that e-services are typically automated, requiring minimal human intervention, and are not viable without information technology. Examples of electronically supplied services include website provision and web hosting, while services such as radio and television broadcasting, telecommunications, and goods ordered and processed electronically are excluded.

To address the research gap in the current study, this research presents a model that explains the relationship between the continued use and adoption of e-governance systems and AI in improving electronic government services. The focus is on the role of transformational leadership as a mediating variable in these relationships. The study aims to answer the following two questions: Does the use of e-governance systems and AI directly improve the delivery of e-government services in the Jordanian public sector? And, does transformational leadership play a significant role as a mediating variable that could influence this relationship? The proposed theoretical framework is shown in Figure 1, followed by subsections that explain and clarify each expected relationship based on scientific literature and previous studies.

Previous studies in the context of emerging technologies, such as artificial intelligence, are significantly limited, particularly in developing countries, including the public sector in Jordan. While many previous studies have addressed these technologies separately, very few have examined them together, especially in the context of the

public sector, and even fewer in the presence of transformational leadership. The research gap in the current study lies in connecting technology with effective leadership to improve the e-services provided by the public sector. Therefore, this study aims to bridge the research gap by finding the intersection and linkage between artificial intelligence and modern technologies in improving e-services through effective leadership capable of steering in the right direction (Torous et al., 2020; Henriksen et al., 2021).

Moreover, the study relies theoretically on focusing on the role of transformational leadership in adopting modern technologies, as previous studies in this context have proven that transformational leadership plays a crucial role in creating an environment conducive to technology adoption in the public sector. Thus, based on the above, the reason and justification for choosing the study question stem from addressing the growing interest in enhancing AI technologies to improve the services provided by the Jordanian public sector. As mentioned earlier, these technologies are emerging and in the early stages of implementation, making this a critical time for exploration and study. It is hoped that this study will provide valuable insights and frameworks regarding the key opportunities and challenges that could face the adoption of AI applications in the Jordanian public sector and contribute to providing recommendations and guidance for policymakers and decision-makers in Jordan and similar countries.

Based on the above, and in alignment with previous literature, the study model and hypotheses are formulated as outlined below:

Study model:

H.1: *There is a statistically significant direct effect of the use of e-governance systems, with their combined dimensions (accountability, participation, transparency), on improving electronic government services in the Jordanian public sector.*

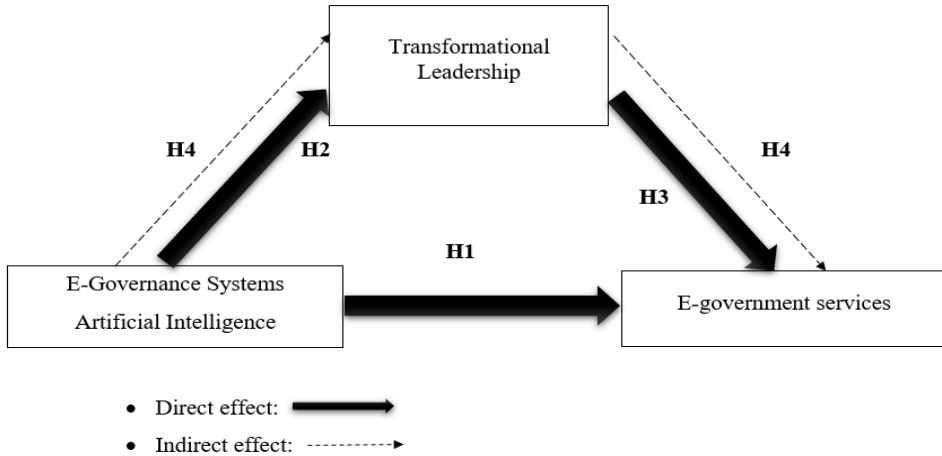
H.2: *There is a statistically significant direct effect of the use of AI, with its combined dimensions (expert systems, neural network systems, genetic algorithm systems), on improving electronic government services in the Jordanian public sector.*

H.3: *There is a statistically significant direct effect of the use of e-governance systems, with their combined dimensions (accountability, participation, transparency), through transformational leadership, on electronic government services with their combined dimensions (service innovation, reliability, trustworthiness) in the Jordanian public sector.*

H.4: *There is a statistically significant direct effect of the use of AI, with its combined dimensions (expert systems, neural network systems, fuzzy logic systems, genetic algorithm systems), through transformational leadership, on electronic government services with their combined dimensions (service innovation, reliability, trustworthiness) in the Jordanian public sector.*

H.5: *Transformational leadership mediates the impact of the use of AI and e-governance systems on the improvement of electronic government services.*

Figure 1 Study model



3 Theoretical framework of the study

AI and e-governance: E-governance involves the use of ICT in the institutional structures of the state, as well as in decision-making processes, and the implementation of various changes in the relationships between the government and citizens (Grigalashvili, 2023). According to Davies (2015), e-governance represents a specialised field focusing on delivering online services directly to individuals, with particular attention to government services such as e-taxation, e-education, and e-healthcare.

As technology advances, AI (AI) emerges as a key element that can significantly enhance these foundations. AI has the capacity to improve data analysis, offer personalised services, and increase the speed and accuracy of decision-making, contributing to the effectiveness and efficiency of e-governance systems. This, in turn, creates a framework for smart governments capable of adapting to future needs (Salama, 2024). To fully grasp the potential of this technology, it is essential to understand the characteristics of AI that impact various aspects of modern life, as outlined in study by Akgun and Greenhow (2022).

The importance of the characteristics of AI (AI) lies in enhancing its effectiveness and efficiency in addressing complex problems and challenges. AI possesses an exceptional ability to analyse, evaluate, and adapt to changing circumstances even in the face of limited information, making it a vital tool for making complex decisions (Hashem and Alqatamin, 2021). Furthermore, AI can learn from past experiences and apply knowledge effectively; it can also use trial and error methods to discover new solutions and quickly adapt to changes. This combination of traits – such as creativity, imagination, and awareness of challenges – integrates elements of managerial decision-making, establishing sustainable success across various sectors (Chaki et al., 2022.).

3.1 E-government and electronic services

Digital government emerged in the 1990s in response to the growing need to adopt new technologies that support government operations. Digital government has seen significant growth over the past decade due to the increasing power of ICT. Governments can now provide services at multiple levels and for a diverse range of individuals, contributing to increased efficiency and savings for governments and businesses, enhanced transparency, and greater public participation in political life (European Commission, 2014). E-government refers to the use of the internet and web resources to enable institutions (whether public or private) and individuals to access government services and information, aiming to enhance the effectiveness and efficiency of service delivery in the public sector (Ali and Anwar, 2021; Dwivedi et al., 2020; González-Bustamante, 2020; Sundberg, 2019).

On the other hand, the concept of e-government is linked to the use of ICT, with this connection clearly reflected in the quality of services provided by the government to citizens (Nawafleh et al., 2012). A study by Chávez-Chica et al. (2021) noted that e-government relies on the use of ICT, enabling genuine reforms in public administration towards modernisation. This transformation focuses on improving the interaction between public administration and users, and due to its innovative nature, e-government allows for the exploration of new aspects in modern governance processes and mechanisms for enhanced efficiency.

The strategic goal of implementing e-government is to enhance the delivery of government services to all stakeholders. ICT connect stakeholders and supports related electronic activities and processes. This means that e-government achieves several key objectives for the public sector by saving time, labour, costs, enhancing skills and improving performance levels and resources (Elsheikh et al., 2008):

3.2 Electronic services

Government services have taken on digital forms, being provided through electronic media via the internet. These are referred to as electronic services, which are interactive and centralised materials aimed at providing support to citizens online, thereby creating collaboration between users and service providers. The use of electronic services is one way to enhance e-government and is a standard for assessing e-government progress in all countries (Danu et al., 2023).

Some researchers have defined electronic services through several concepts. For instance, Karolak et al. (2021) pointed out that government agencies have the capacity to exchange information among themselves, in addition to providing services to citizens and the public sector quickly through internet networks. They also ensure the confidentiality and security of exchanged information at any time and from anywhere.

On the other hand, Mustafa et al. (2020) described electronic service as the process of conducting administrative and governmental tasks online, where e-government entities provide their services to citizens without the need to visit government offices. These services can be executed from home or from anywhere in the world through the internet, aiming to save time, effort, and money.

Carlson and O'Cass (2010) indicated that electronic service is considered a form of self-service, where the citizen is required to serve themselves instead of submitting a request to a staff member behind a desk or contacting someone by phone to obtain

information or inquiries. The service is obtained through an automated and direct interaction between the service requester and provider via technology media.

The concept of electronic services is a contemporary model in the digital environment that encompasses both the industrial and governmental sectors and consists of three main elements: The first element is that institutions communicate with citizens through a business-to-consumer (B2C) model in the business world; whereas in the governmental sector, interaction with citizens is known as government-to-consumer (G2C). The second element takes place within the institution organisationally and is known as internal electronic services. The third element pertains to relationships with external parties such as suppliers or the government, which is known as B2B or B2G within the scope of the governmental domain. Interactions with the business world and governmental agencies are termed G2B or G2G. These interactions can include various elements such as information exchange, negotiation meetings, promotional campaigns, and products or services. As a result, electronic services have become increasingly popular, especially among academics and practitioners who seek to understand how to leverage the internet environment to develop a successful electronic service system that meets user needs (Ead and Abbassy, 2021).

3.3 Transformational leadership and e-government services

In the context of e-government services, transformational leadership can help align technological developments with institutional goals and ensure that the implementation of e-governance systems and AI tools achieves improvements in the services provided (Pedersen, 2018). Furthermore, Transformational leadership is closely linked to e-government services, as it plays a key role in the successful implementation and development of e-government initiatives. (Mahmood et al., 2018) Transformational leaders inspire their teams and motivate them to think creatively and innovate, practicing new technologies such as AI and e-governance tools (O'Neill, 2009). They also foster a culture of continuous improvement, encourage collaboration, and support the strategic use of technology to meet public needs (Prawati and Augustine, 2022). Transformational leaders possess creative thinking and the ability to lead the public sector by navigating the complexities of digital transformation, addressing challenges such as resistance to change, skill shortages, and resource allocation, while effectively communicating the benefits of e-government services and empowering the teams responsible for them (Stein, 2022).

The technological applications are integral to the digital transformation strategy aimed at improving the public sector and providing citizens with more efficient and transparent services by facilitating the flow of information, reducing bureaucracy, and ensuring ease of access to services through e-government systems capable of enhancing government operations management and providing a smoother and more effective experience for citizens (Samuel et al., 2023). On the other hand, AI applications increase the capabilities of these systems by providing innovative solutions based on big data analytics and machine learning, helping the government anticipate future needs and make informed decisions (Shields, 2024). However, transformational leadership is a key enabling factor for maximising the benefits of these technologies, as it helps effectively integrate e-governance systems and AI by guiding government teams to adapt to these technologies, overcome resistance to change, and improve the citizen's experience with electronic services (Van Noordt and Misuraca, 2022).

In conclusion, many studies and previous literature have addressed these topics separately, very few have examined them collectively, especially in the context of the public sector and under the influence of transformational leadership. The research gap in the current study lies in linking technology with effective leadership to improve the electronic services provided by the public sector. Therefore, this study aims to bridge the research gap by identifying intersections and connections between AI and modern technologies in enhancing electronic services through the provision of effective leadership capable of steering efforts in the right direction.

4 Methodology

The study adopted a quantitative exploratory descriptive approach that aims to explore and provides a description of the phenomenon and analyses its elements, the convenience sample was used because the research follows an exploratory design, and the topic of the study, which focuses on AI techniques and e-governance, is rare in the Jordanian public sector due to its novelty. Additionally, not all employees in the Jordanian public sector are familiar with these technologies, which is why this type of sample was chosen. variables, and factors influencing it by exploring the views a group of individuals related to the subject of the phenomenon being investigated, the quantitative approach requires the availability of information and data associated with the phenomenon studied in order to make the researcher able to reach conclusions that may help to understand the phenomenon. Due to the lack of research on the current topic, the exploratory methodology is appropriate. The study employs a cross-sectional quantitative approach, which uses a questionnaire to examine the relationship between variables to obtain primary data in a single time period rather than over an extended time period (Sekaran and Bougie, 2016). The questionnaire was used to collect the primary data from the respondents, which is considered the most suitable data collection tool and most used in the descriptive research and survey methodologies. The population and the unit of analysis for this study comprised all Jordanian employees in the governorate of the country. A total of 305 questionnaires were collected based on the method of convenience sampling.

The data collection process for the study was conducted in a manner that ensured adherence to the accuracy and ethical and scientific standards followed in research methodology. Multiple methods were employed, including surveys and personal interviews with individuals from the study sample who possess knowledge and experience in emerging technologies such as (AI) and e-governance. The sample included departments of information technology, AI, and e-governance within ministries and public institutions, as well as some decision-makers in the Jordanian public sector. The survey and interview questions were reviewed and validated by a group of experienced academic professors and adjusted based on their feedback. To ensure easy access to the study sample, the survey was distributed electronically using a convenience sampling method, following coordination with the human resources departments of various ministries and public institutions.

Additionally, a pilot test was conducted with a small group from the sample to ensure the clarity and suitability of the survey items. To further ensure adherence to ethical and scientific standards, the study objectives were explained and clarified before the final data collection phase. During this stage, it was emphasised that participation in

completing the survey was voluntary, ensuring the confidentiality and privacy of participant information. Participants were also informed of their right to withdraw from the study at any time, contributing to the credibility of the research.

4.1 Descriptive statistics

As shown in Table 1 majority of the participants were male (52.1%), indicating a gender imbalance in public sector employment, which could be influenced by cultural and social norms favouring men in certain job categories. This points to the importance of promoting gender equality in recruitment. The most represented age group was 41–50 years (46.9%), suggesting that the data predominantly reflects the opinions of experienced employees. However, younger age groups were less represented, which could imply underrepresentation of their perspectives on technology and leadership. Additionally, 52.8% of participants held a bachelor's degree, underscoring the importance of higher education for government employment and reflecting the participants' ability to critically assess government services. Most respondents were employees (46.9%), which shows that the data mainly reflects the views of those with direct interaction with government services, while only 3.6% were assistant managers, indicating lower representation in leadership positions. Furthermore, 56.1% of participants had over 16 years of experience, reflecting the stability of public sector jobs but also suggesting a gap in recruitment or promotion among mid-career employees with 11–15 years of experience.

Table 1 Sample profile

<i>Variable</i>	<i>Category</i>	<i>Frequency</i>	<i>Percentage (%)</i>
Gender	Male	159	52.10
	Female	146	47.90
Age	Less than 30 years	12	3.90
	31- less than 40 years	96	31.50
	41- less than 50 years	143	46.90
	51 years or more	54	17.70
Education	Diploma or less	32	10.50
	Bachelor degree	161	52.80
	Master degree	81	26.60
	PhD degree	31	10.20
Job Title	Employee	143	46.90
	Assistant Manager	11	3.60
	Head of Department	74	24.30
	Manager	77	25.20
Years of experience	Less than 5 years	53	17.40
	6- less than 10 years	41	13.40
	11-less than 15 years	40	13.10
	16 years or more	171	56.10

4.1.1 Descriptive statistics and distribution analysis

All variables, including accountability (4.056), transparency (4.095), and electronic government services (3.946), had mean values above the theoretical average of 3, indicating positive perceptions within the public sector. Skewness and kurtosis values were within the acceptable range (± 3), confirming that the data distribution is normal and supports the validity of the findings.

4.2 Reliability

The reliability of the scales was assessed using Cronbach's alpha and composite reliability (CR).

Cronbach's alpha and composite reliability were calculated for each variable. Acceptable values for both indices are 0.70 or higher (Hair et al., 2019) and Table 2 shows the results of the reliability analysis.

Table 2 Cronbach's alpha and composite reliability (CR)

<i>Variables</i>	<i>Cronbach's alpha</i>	<i>Composite reliability (CR)</i>
Accountability	0.905	0.929
Participation	0.903	0.929
Transparency	0.929	0.944
Neural Networks	0.906	0.934
Expert Systems	0.947	0.959
Genetic Algorithms	0.938	0.956
Government Services	0.961	0.965
Transformational Leadership	0.962	0.967

Based on Table 3 all the values exceeded 0.70, indicating high reliability of all scales used in the study.

Table 3 Results of the reliability analysis for the study variables

<i>Variables</i>	<i>Arithmetic mean</i>	<i>Standard deviation</i>	<i>Skewness</i>	<i>Kurtosis</i>
Accountability	4.056	0.733	-1.097	2.091
Participation	3.771	0.846	-0.744	0.654
Transparency	4.095	0.765	-1.194	1.942
Neural networks	3.933	0.879	-1.166	1.453
Expert systems	3.689	0.924	-0.764	0.641
Genetic algorithms	3.784	0.884	-0.881	0.772
Government services	3.946	0.733	-1.08	2.17
Transformational leadership	3.806	0.879	-0.958	1.319

4.3 Discriminant validity

Discriminant validity is achieved according to the Fornell-Larcker criterion when the square root of the AVE of each variable is greater than its correlations with other variables (Fornell and Larcker, 1981) and Table 4 shows the results of the Fornell-Larcker analysis.

Table 4 Results of the Fornell-Larcker analysis

<i>Fprnell-Larcker</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Accountability	0.851							
(2) Participation	0.710	0.851						
(3) Transparency	0.773	0.713	0.859					
(4) Neural Networks	0.610	0.578	0.651	0.883				
(5) Expert Systems	0.546	0.605	0.599	0.706	0.908			
(6) Genetic Algorithms	0.642	0.600	0.621	0.696	0.766	0.919		
(7) Government Services	0.693	0.658	0.746	0.642	0.665	0.667	0.826	
(8) Transformational Leadership	0.586	0.665	0.624	0.554	0.575	0.580	0.710	0.875

The results in Table 4 indicate that the square root of the AVE for each variable (the shaded values on the diagonal) is greater than its correlations with the other variables, supporting the validity of the discriminant according to the Fornell-Larcker criterion.

4.3.1 Heterotrait-Monotrait (HTMT) correlation ratio

HTMT correlation ratio was used as an additional criterion to assess discriminant validity. According to Henseler et al. (2015), HTMT values should be less than 0.90 to achieve discriminant validity and Table 5 shows the results of HTMT analysis.

Table 5 Results of HTMT correlation ratio analysis

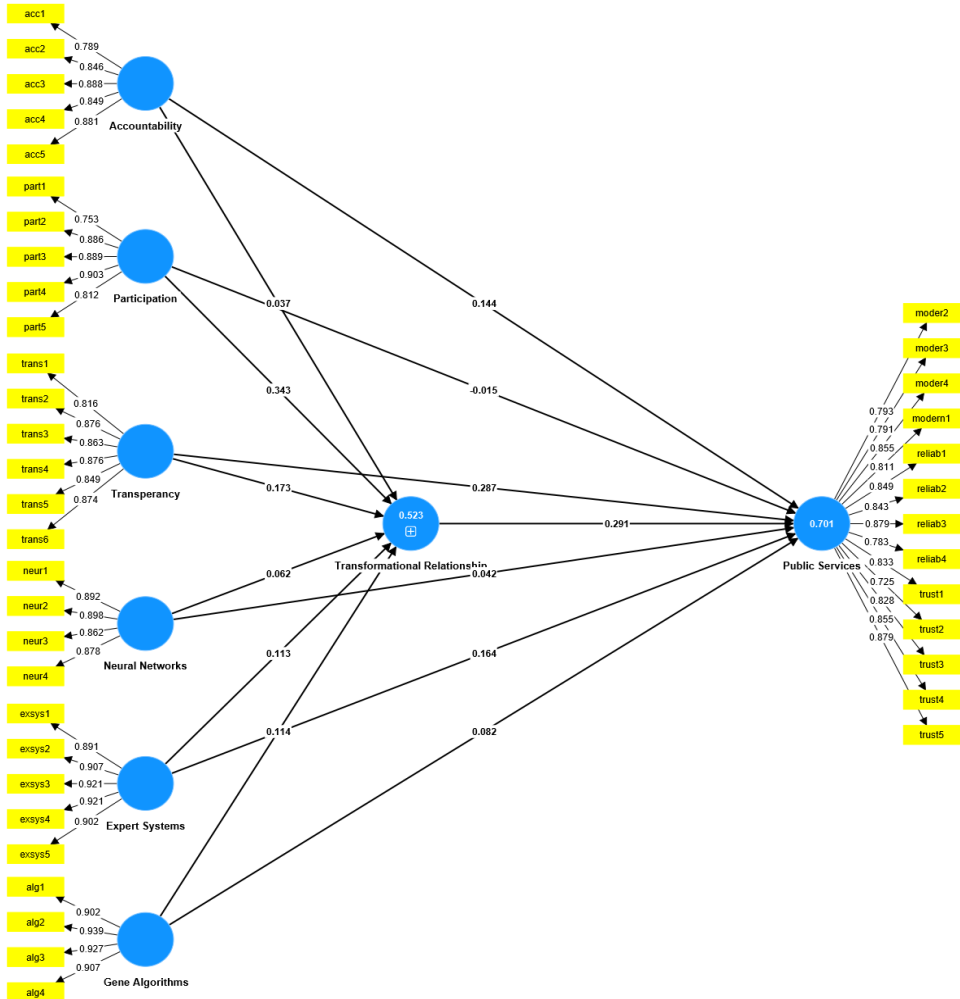
<i>HTMT</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Accountability								
(2) Participation	0.787							
(3) Transparency	0.843	0.777						
(4) Neural Networks	0.667	0.635	0.704					
(5) Expert Systems	0.587	0.658	0.634	0.764				
(6) Genetic Algorithms	0.697	0.655	0.664	0.753	0.811			
(7) Government Services	0.741	0.704	0.785	0.673	0.693	0.700		
(8) Transformational Leadership	0.629	0.711	0.657	0.584	0.602	0.610	0.734	

Based on Table 5 all HTMT values were less than 0.90, confirming the validity of the discriminant validity between the study variables according to the HTMT criterion for the correlation ratio (Henseler et al., 2015).

4.4 Structural model evaluation

After verifying the validity and reliability of the measurement model, the structural model was evaluated using Smart PLS 4. Figure 2 shows the study model with path coefficients and coefficients of determination (R^2).

Figure 2 Study model with path coefficients and coefficients of determination (see online version for colours)



4.4.1 Coefficient of determination (R^2)

The coefficient of determination (R^2) measures the explanatory power of the model (Hair et al., 2019). Table 6 shows the R^2 values for the dependent variables in the model.

Table 6 Coefficient of determination (R^2) values for the dependent variables

<i>Dependent variable</i>	R^2	<i>Explanation of explanatory power</i>
Transformational leadership	0.523	Medium
E government Services	0.701	Medium

According to Hair et al. (2011), R^2 values of 0.75, 0.50, and 0.25 are considered large, medium, and weak, respectively. The results indicate that the model has moderate explanatory power for transformational leadership and e-government services.

4.4.2 Effect size (f^2)

Effect size (f^2) measures the extent to which the independent variable affects the dependent variable (Cohen, 1988). Table 7 shows the f^2 values for the main relationships in the model.

Table 7 Effect size (f^2) values for the main relationships

<i>Relationship</i>	f^2	<i>Effect size</i>
Accountability → Government Services	0.024	Small
Participation → Government Services	0.000	No effect
Transparency → Government Services	0.092	Small
Neural Networks → Government Services	0.029	Small
Expert Systems → Government Services	0.002	Slight
Genetic Algorithm → Government Services	0.007	Slight
Accountability → Transformational Leadership	0.001	Slight
Participation → Transformational Leadership	0.111	Small
Transparency → Transformational Leadership	0.024	Small
Neural Networks → Transformational Leadership	0.01	Slight
Expert Systems → Transformational Leadership	0.003	Slight
Genetic Algorithm → Transformational Leadership	0.01	Slight
Transformational Leadership → Government Services	0.133	Small

According to Cohen (1988), f^2 values for effect size of $0.02 \leq 0.15 \leq 0.35$ are considered small, medium, and large, respectively. Values less than 0.02 are considered to have a small or no effect. These results help in understanding the relative importance of each independent variable in explaining the dependent variables in the model.

4.4.3 Predictive ability of the model (Q^2)

Stone-Geisser's Q^2 value was used to evaluate the predictive ability of the model (Geisser, 1974; Stone, 1974). Table 8 shows the Q^2 values for the dependent variables.

Table 8 Predictive ability (Q^2) values for the dependent variables

<i>Dependent variable</i>	Q^2	<i>Predictive ability</i>
Transformational leadership	0.412	Matching
E government services	0.486	Matching

Q^2 values greater than zero indicate good predictive ability of the model (Hair et al., 2019). The results confirm the good predictive ability of the model.

5 Hypothesis testing

The hypotheses regarding the direct effects were tested using path analysis in Smart PLS 4 and Table 9 summarises the results of hypothesis testing for the direct effects.

Table 9 Hypothesis testing results for the direct effects

<i>Hypothesis</i>	<i>Path</i>	<i>Path coefficient (β)</i>	<i>T value</i>	<i>P-value</i>	<i>Result</i>
H1.1	Accountability → Government Services	0.144	2.198	0.028	Supported
	Participation → Government Services	-0.015	0.245	0.806	Unsupported
	Transparency → Government Services	0.287	4.847	0.000	Supported
H1.2	Expert Systems → Government Services	0.164	2.745	0.006	Supported
	Neural Networks → Government Services	0.042	0.751	0.453	Unsupported
	Genetic Algorithms → Government Services	0.082	1.223	0.221	Unsupported
H2.1	Accountability → Transformational Leadership	0.037	0.443	0.658	Unsupported
	Participation → Transformational Leadership	0.343	4.688	0.000	Unsupported
	Transparency → Transformational Leadership	0.173	1.967	0.049	Supported
H2.2	Expert Systems → Transformational Leadership	0.113	1.648	0.099	Supported
	Neural Networks → Transformational Leadership	0.062	0.832	0.405	Unsupported
	Genetic Algorithms → Transformational Leadership	0.114	1.536	0.124	Unsupported
H3	Transformational Leadership → Government Services	0.291	4.708	0.000	Supported

Previous table the direct effects on Electronic Government Services, accountability had a significant positive effect on electronic government services ($\beta = 0.144$, $T = 2.198$, $p = 0.028$), suggesting that accountable systems and employees lead to improved government services. Participation, however, did not have a significant impact ($\beta = -0.015$, $T = 0.245$, $p = 0.806$), indicating that it may not directly influence service effectiveness. Transparency showed a strong positive effect ($\beta = 0.287$, $T = 4.847$, $p = 0.000$), highlighting the importance of open communication in enhancing electronic services. Expert systems also had a positive relationship ($\beta = 0.164$, $T = 2.745$, $p = 0.006$), suggesting their usefulness in improving service performance. Conversely, neural networks ($\beta = 0.042$, $T = 0.751$, $p = 0.453$) and genetic algorithms ($\beta = 0.082$, $T = 1.223$, $p = 0.221$) did not have significant effects, indicating a potential gap in the integration of these advanced AI technologies within the public sector.

The mediating role of transformational leadership was tested using bootstrapping method. Table 10 summarises the results of testing the mediation hypotheses.

Table 10 Results of testing the indirect effects (mediation) hypotheses

<i>Hypothesis</i>	<i>Indirect path</i>	<i>Indirect effect</i>	<i>T value</i>	<i>P-value</i>	<i>Result</i>
H4.1	Accountability → Transformational Leadership → Government Services	0.011	0.435	0.664	Supported
	Participation → Transformational Leadership → Government Services	0.100	3.358	0.001	Unsupported
	Transparency → Transformational Leadership → Government Services	0.050	1.758	0.079	Supported
H4.2	Expert Systems → Transformational Leadership → Government Services	0.033	1.596	0.110	Supported
	Genetic Algorithms → Transformational Leadership → Government Services	0.033	1.365	0.172	Unsupported
	Neural Networks → Transformational Leadership → Government Services	0.018	0.794	0.427	Unsupported

Accountability did not significantly impact transformational leadership ($\beta = 0.037$, $T = 0.443$, $p = 0.658$), suggesting it may not directly enhance leadership qualities in this context. However, participation had a strong positive effect ($\beta = 0.343$, $T = 4.688$, $p = 0.000$), emphasising the role of employee involvement in fostering transformational leadership. Transparency also had a positive impact ($\beta = 0.173$, $T = 1.967$, $p = 0.049$), showing that open communication helps develop leaders who guide organisational change. Expert systems ($\beta = 0.113$, $T = 1.648$, $p = 0.099$) and genetic algorithms ($\beta = 0.114$, $T = 1.536$, $p = 0.124$) did not significantly influence leadership, while neural networks ($\beta = 0.062$, $T = 0.832$, $p = 0.405$) also had no significant effect, further indicating limited AI technology integration in leadership development.

6 Discussion

The results of the previous analysis showed that accountability and transparency have a significant positive impact on government services, confirming the importance of clear responsibility and open communication in improving the performance of the public sector. Accountability (H1.1: $\beta = 0.144$, $p = 0.028$) indicates that when systems and employees are held accountable, it leads to improved government services, due to increased trust and reliability. This result leads to greater trust in e-government services and increased adoption by users. Similarly, transparency (H1.1: $\beta = 0.287$, $p = 0.000$) proved to be even more influential, confirming that the availability of information and open communication significantly enhance service delivery. This result aligns with previous research on the value of transparency in e-government contexts. Furthermore, expert systems (H1.2: $\beta = 0.164$, $p = 0.006$) showed a positive relationship with service performance, supporting the role of AI in streamlining processes and decision-making in the public sector. This suggests the importance of integrating AI technologies in delivering e-services in the public sector, as it plays a major role in improving e-services for both service recipients and government institutions and employees. Additionally, transformational leadership had a strong positive effect on government services (H3: $\beta = 0.291$, $p = 0.000$), highlighting the critical role of visionary leaders in fostering innovation and improving service quality through digital platforms. It is necessary to provide recommendations to decision-makers and continuously encourage them to adopt such leadership.

Regarding the transformational leadership variable, transparency (H2.1: $\beta = 0.173$, $p = 0.049$) again played a significant role in this context, suggesting that open communication within government institutions can enhance and encourage leadership that drives change towards adopting AI systems and digital transformation. Expert systems (H2.2: $\beta = 0.113$, $p = 0.099$) also approached significance, indicating the potential for further AI integration to enhance leadership. There is also a need to explore new variables in future research that could strengthen this area.

The results of the previous analysis also showed that participation did not have a significant impact on government services (H1.1: $\beta = -0.015$, $p = 0.806$), which contrasts with expectations that increasing employee or citizen involvement would directly improve service outcomes. This may suggest that the effects of participation are more indirect or dependent on other factors, which could be explored in previous studies that were not referenced, and included in future recommendations when conducting other studies in this context. The analysis also showed that the accountability variable (H2.1: $\beta = 0.037$, $p = 0.658$) did not significantly affect transformational leadership, indicating that while accountability improves services directly, it does not seem to foster leadership development in this context. As mentioned earlier, it is important to investigate the reasons for this and include them in future studies.

Similarly, the analysis related to neural networks (H1.2: $\beta = 0.042$, $p = 0.453$) and genetic algorithms (H1.2: $\beta = 0.082$, $p = 0.221$) did not show significant effects on government services, suggesting limited integration of advanced AI technologies in the public sector or potential challenges in their implementation. This result could be justified by the lack of maturity and understanding of the role of these variables by employees and those responsible in the public sector. The results also indicated that these technologies did not have a significant effect on transformational leadership (H2.2), suggesting that more advanced applications or support systems may be required to fully

leverage AI's potential in leadership contexts. This leads to the necessity of deeply exploring previous studies on these variables to understand the reasons for the lack of impact in the context of this study and to provide recommendations to decision-makers in the public sector for future improvements.

In the terms of mediation, although transformational leadership played a strong mediating role regarding transparency and participation in improving government services (H4.1, H4.2 and H5), it did not mediate the relationship between accountability and services, nor between genetic algorithms and services. This justifies the need to provide recommendations aimed at strengthening leadership frameworks and exploring stronger technologies to enhance these relationships. In this context, it is necessary to offer recommendations to those responsible for e-government programs to investigate the reasons behind these findings and consider them when planning future initiatives related to AI and e-government in the public sector.

The study's findings highlighted the significant importance of emerging technologies such as artificial intelligence and e-governance. Decisions based on these technologies enhance the efficiency and quality of electronic services provided by the public sector in Jordan and contribute to better resource allocation. This finding aligns with previous studies, such as Henriksen et al. (2021).

The results also revealed that the use of transformational leadership and emerging technologies significantly improves public services, as indicated by studies like Schapke et al. (2020) in developed countries such as the Netherlands and Latin America. Conversely, studies focusing on developing countries, such as Heeks (2002) in South Africa, identified significant challenges in implementing these strategies, highlighting the need for tailored mechanisms to ensure their successful execution.

Regarding transformational leadership, the current study demonstrated its critical role in adopting emerging technologies, surpassing other leadership styles like *laissez-faire* and transactional leadership. These styles were found to be less adaptable in dealing with such technologies, as they involve less active engagement from leaders, a point supported by Podsakoff et al. (1990) findings.

7 Study implications

This study is one of the few and important studies that has not been addressed by researchers before, as it explores a range of variables that have not been covered in previous studies. The study highlights the role of transformational leadership, which emerged as a vital variable for improving e-government services. This phase, especially in developing countries, Decision-makers and leaders in the Jordanian public sector must adopt transformational leadership, acquiring the necessary skills to inspire employees toward embracing emerging technologies. Additionally, it is essential to highlight the importance of transitioning to technology and e-governance, given their significant role in enhancing the speed and accuracy of administrative decision-making and addressing delays and bureaucracy within the Jordanian public sector. The study is an excellent.

8 Future research

This study provides vital recommendations for researchers, emphasising the need to explore more advanced AI techniques to improve government services. The study also recommends examining the evolution of transformational leadership and its impact on service delivery over time, which would offer deeper insights into its mediating role. Cross-cultural comparisons could help verify whether the findings related to accountability, transparency, and participation apply across different governance contexts. Additionally, refining measures for participation and related constructs could better capture their effects on government services, while studying the impact of organisational factors like culture and policy could further shed light on the relationship between AI, leadership, and services.

9 Study limitations

From reviewing the study's findings, some limitations can be observed. One key issue is the lack of impact of some variables, indicating the need for further studies that address other more impactful variables. Advanced AI techniques, such as neural networks and genetic algorithms, did not have a significant effect on government services or transformational leadership, likely due to limited integration and the maturity of AI in the public sector. The study's sample size might also have contributed to the lack of significant impact, and increasing the sample size in future studies would make the findings more representative and generalisable. One clear limitation is the study's focus on a single country or region, which may affect the generalisability of its results.

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