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Digital transformation and AI in Moroccan cities: Pathways to smart urban governance

Najoua El Abbas El Ghaleb[1*], Anass Cherti[2], Insaf Jouiet[3], Mohamed Kharbach[4], Fadoua Laghzaoui[5]
[1,5]Faculty of Legal, Economic and Social Sciences, Tangier, Abdelmalek Essaadi University, Morocco, elabbasnajoua@uae.ac.ma (N.E.A.E.G.) flaghzaoui@uae.ac.ma (F.L.)
[2,4]Faculty of Legal, Economic and Social Sciences, Tetouan, Abdelmalek Essaadi University, Morocco; cherti.anass@gmail.com (A.C.) kharbach2222@gmail.com (M.K.)
[3]Faculty of Legal, Economic and Social Sciences, Oujda, Mohamed First University, Morocco, jouiet.insaf@ump.ac.ma (I.J.)

Abstract: The pervasive influence of digital transformation and artificial intelligence (AI) is fundamentally reshaping urban management paradigms. These technologies offer novel approaches to improving public service efficiency, enhancing data accessibility, fostering citizen participation, and bolstering urban resilience. This research investigates the specific impacts of these technological advancements on the governance of Moroccan cities. Employing structural equation modeling (SEM) with data gathered from 320 respondents within the Tanger-Tétouan-Al Hoceïma region, we empirically assess these relationships. The analysis reveals a substantial positive association between digital transformation and both public service efficiency ($\beta = 0.60$, $p < 0.01$) and data accessibility ($\beta = 0.55$, $p < 0.01$). Similarly, AI adoption demonstrates a significant contribution to urban resilience ($\beta = 0.50$, $p < 0.01$) and the optimization of urban infrastructure management. However, the influence of AI on citizen engagement appears comparatively modest ($\beta = 0.20$, $p < 0.05$), suggesting a critical need for complementary strategies focused on digital inclusion and public awareness. While technological progress is evident, persistent challenges remain, including suboptimal inter-institutional coordination, persistent digital divides, and limitations in the availability of real-time, open data. To realize the full potential of digital transformation, public policies should prioritize information system interoperability, transparency in municipal decision-making processes, and the active involvement of citizens in urban governance. This study provides empirical insights into the evolving landscape of smart cities in Morocco, underscoring the necessity of an integrated, holistic approach to maximize the benefits of digital technologies in urban administration. Future scholarly inquiry could profitably examine the longitudinal evolution of these impacts and conduct comparative analyses of the performance of diverse Moroccan cities in the context of smart city development.

Keywords: *Artificial intelligence, Digital transformation, Morocco, SEM model, Smart cities, Urban management.*

1. Introduction

In an era of heightened complexity, digital transformation and artificial intelligence (AI) have become pivotal in reshaping urban governance and enhancing the daily lives of city dwellers [1]. With an increasing number of municipal functions transitioning to digital platforms, cities can now operate with greater efficiency, transparency, and responsiveness to the evolving needs of their residents [2]. AI's ability to process and derive insights from extensive urban datasets facilitates proactive, data-driven decision-making, empowering city administrators to address emerging challenges with greater precision [3].

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* Correspondence: elabbasnajoua@uae.ac.ma

Morocco has actively embraced this digital shift by promoting smart city initiatives and implementing national digital transformation strategies. Major urban hubs such as Casablanca, Rabat, and Tangier are leveraging advanced technologies—including the Internet of Things (IoT), Big Data analytics, and AI—to enhance urban services [4]. A notable example is Tangier's AI-driven traffic management system, which dynamically adapts to real-time conditions, mitigating congestion and improving mobility [5].

Despite these advancements, there remains a critical need to assess their concrete impact on urban governance in Morocco. To address this gap, the present study employs structural equation modeling (SEM) to analyze the influence of digital transformation and AI on urban management strategies. SEM enables the identification of key success factors in Moroccan smart city projects, ranging from optimizing public service delivery and enhancing data accessibility to fostering civic engagement and bolstering urban resilience.

By gathering and analyzing quantitative data from various urban stakeholders and residents, this research seeks to provide insights into how digital and algorithmic innovations are reshaping local governance. The study's findings will contribute to the development of data-driven policies and strategies, ultimately facilitating a more efficient, inclusive, and sustainable digital evolution for Moroccan cities.

2. Literature Review

2.1. Digital Transformation, Artificial Intelligence, and Urban Management

Recent conversations surrounding smart cities and digital urban governance highlight the transformative role of information and communication technologies (ICT) and artificial intelligence (AI) in modernizing municipal services. This shift relies on interconnected infrastructure, efficient data-sharing networks, and intelligent systems that optimize resource management while enhancing everyday life for city residents [3].

Research increasingly demonstrates that integrating AI into urban management leads to better anticipation of infrastructure demands, smoother traffic flow, and greater resilience against unexpected disruptions [2]. Smart cities distinguish themselves by leveraging ICT and AI to improve various urban functions, from governance and environmental sustainability to the efficient delivery of public services Alawadhi, et al. [1]. Nam and Pardo [6] provide a framework for understanding this transformation, built on three key pillars: (1) Technology, which encompasses digital infrastructure and data systems; (2) Governance, emphasizing citizen engagement and transparency; and (3) Sustainability, focusing on energy management and responsible environmental practices.

In Morocco, several municipalities are actively working to digitize public services and implement AI-powered tools [4]. Cities like Casablanca, Rabat, and Tangier are leading the way, employing online platforms, smart traffic control systems, and real-time data analytics to inform urban planning decisions [5]. However, despite these advancements, significant challenges remain in fully realizing the potential of these technologies. Key obstacles include a lack of coordination among urban stakeholders, disparities in digital access affecting certain communities, and ongoing concerns about data transparency and accessibility [7].

2.2. Use of Structural Equation Modeling (SEM) in Smart City Analysis

Structural Equation Modeling (SEM) has emerged as a widely recognized tool for investigating digital technology adoption in urban management. Its principal appeal lies in its ability to analyze numerous intricate relationships among a broad array of variables [8]. Because SEM allows for the concurrent testing of interrelated hypotheses, incorporating both latent (unobserved) and observed (directly measured) variables, it proves especially useful in studying the multifaceted impacts of digital innovations within smart city settings. In particular, SEM offers an effective way to gauge how digital solutions influence aspects such as efficient service delivery, public participation in local governance, and the sustainability of urban infrastructure [9]. An illustrative example can be found in Keawsomnuk

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[10] who used an SEM approach to highlight how core smart city elements significantly affect the management of urban infrastructure and, ultimately, raise the overall standard of living for city dwellers. Likewise, Alkdour, et al. [9] applied an SEM framework rooted in the Technology Acceptance Model (TAM) to probe factors that drive citizens' use of digital services. Their research underscores the importance of digital trust, security perceptions, and the general quality of service in determining how readily individuals adopt smart city platforms. Although SEM-based analyses aimed at understanding the effects of digital transformation and AI on urban governance in Morocco remain relatively scarce, some scholars have begun to address this gap. Belhaj [11] for instance, employed a Partial Least Squares SEM (PLS-SEM) model to identify key elements of financial governance within Moroccan municipalities. This work showed that financial autonomy, coordination among institutions, well-planned strategies, and effective budgetary oversight all serve as significant enablers of sustainable urban management. Building on these prior efforts, the present study uses an SEM methodology to thoroughly assess the influence of digital transformation and AI on four central components of urban management:

1. Public Service Efficiency
2. Data Accessibility
3. Citizen Engagement
4. Urban Resilience

The overall aim is to generate solid, empirical insights that can help inform public policy decisions and refine the practical implementation of digital solutions.

2.3.1. Digital Transformation (DT)

Digital transformation in municipal governance involves leveraging digital solutions to enhance public service efficiency, promote transparency, and foster citizen engagement [2]. This process includes digitizing local government operations, implementing digital platforms for urban management, and integrating emerging technologies such as the Internet of Things (IoT), cloud computing, and open data [1].

In Morocco, cities like Casablanca, Rabat, and Tangier have launched various digital initiatives, including electronic administrative systems and the use of Geographic Information Systems (GIS) to support urban planning [5]. However, the widespread adoption of these technologies continues to face significant challenges. Key barriers include limited institutional coordination, persistent digital disparities, and the absence of a clear regulatory framework to guide implementation [7].

2.3.2. Artificial Intelligence (AI) in Urban Management

AI is increasingly used to analyze massive urban data and automate strategic decision-making in urban management [3]. For instance, machine learning algorithms optimize urban traffic management, enhance public safety through intelligent surveillance systems, and predict infrastructure needs [9]. In Moroccan cities, pilot projects have been launched to integrate AI into urban infrastructure management. In Tangier, for example, an intelligent traffic light system has been implemented to automatically adjust signal durations based on real-time traffic flow [5]. However, the development of AI in Moroccan urban settings remains hindered by the scarcity of open data and the lack of specialized expertise within public administrations [7].

2.3.3. Public Service Efficiency

One of the primary goals of smart cities is to improve the efficiency of urban services, leading to faster, more reliable, and cost-effective municipal services [2]. The optimization of infrastructure and resources through digital solutions helps reduce administrative delays, simplify processes, and enhance coordination among municipal services [4]. In Morocco, the digitalization of administration has improved certain services, such as the issuance of civil status documents via online platforms. However,

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accessibility and system interoperability remain significant challenges, especially in medium-sized cities where digitalization is still in its infancy [7].

2.3.4. Data and Information Accessibility

Access to urban data is a key factor for transparency, citizen participation, and smart city management [6]. A city that provides open data on its infrastructure, budgets, and services allows citizens and businesses to innovate and actively participate in local governance [2]. In Morocco, although some urban data platforms exist, their usage remains limited due to the absence of a coherent national open data policy. Most municipal information is not available in real-time, restricting the effectiveness of urban analysis and innovation in public services [7].

2.3.5. Citizen Engagement

One of the objectives of smart cities is to strengthen citizen involvement in urban management through interactive technologies [1]. This engagement can take various forms, such as participation in online consultations, co-creation of urban projects through digital platforms, or the use of citizen applications to report urban issues [11]. However, in the Moroccan context, several studies indicate that digital transformation does not automatically lead to increased citizen engagement. Socio-cultural barriers, lack of transparency in decision-making, and limited awareness of digital tools still hinder the adoption of participatory mechanisms [4].

2.3.6. Urban Resilience

Urban resilience refers to the capacity of cities to anticipate, absorb, and recover from crises, including natural disasters, pandemics, and economic downturns [3]. Digital technologies and AI can play a crucial role in enhancing resilience by providing predictive tools for risk management, early warning systems, and coordinated emergency response platforms [2]. Cities like Amsterdam and Singapore have already implemented digital twins to model disaster scenarios and optimize infrastructure responses in real time [10]. In Morocco, although some cities are beginning to integrate these technologies, digital urban resilience remains at an experimental stage and requires a more structured strategic framework [7].

3. Methodology

3.1. Study Area and Data Acquisition Procedures

His research was conducted in Morocco, focusing on urban centers that have actively embraced digital transformation. The Tanger-Tétouan-Al Hoceima region was specifically chosen due to its visible commitment to smart city principles, as evidenced by ongoing programs aimed at digitizing municipal services, integrating AI into various administrative processes, and implementing cutting-edge tools to bolster both urban resilience and the efficiency of public services [4]. Data were collected via a carefully designed survey, capturing insights from both city officials and residents on how digital transformation and AI are influencing urban governance. The questionnaire items drew upon well-established scales in the literature on smart cities and digital governance [8]. To ensure reliable measurements, each latent variable in the conceptual framework was represented by at least three indicators, each rated on a five-point Likert scale from “strongly disagree” to “strongly agree.” Participants were divided into two main groups:

3.1.1. Municipal Officials and Local Government Personnel

This group comprised individuals directly involved in planning, managing, and overseeing digital transformation initiatives. Participants included IT system administrators, smart city project leads, and technical or urban planning staff. Their insights were crucial in understanding how these initiatives are implemented and their impact on urban service delivery.

3.1.2. Citizen Users of Municipal Digital Services

This category included residents who frequently use online municipal platforms or live in designated pilot areas for smart city projects. Their participation provided valuable user-centered perspectives on service efficiency, data accessibility, and overall citizen engagement in digital governance.

The final dataset consisted of 320 respondents, including 140 municipal officials and 180 citizen participants. A quota sampling method was used to ensure a balanced representation from both groups. Data collection combined an online survey (Google Forms) with on-site engagement during smart city workshops held in 2024. This multi-method approach aimed to maximize response rates and secure a diverse and representative sample.

3.2. Conceptual Model and Hypotheses Development

This research employs a structural equation modeling (SEM) approach to rigorously assess the impacts of both digital transformation (DT) and artificial intelligence (AI) on four fundamental dimensions of urban management:

- Public Service Efficiency
- Data and Information Accessibility
- Citizen Engagement
- Urban Resilience

Building on insights from previous research on smart cities and digital governance [1, 2, 9] the following research hypotheses were developed to guide the empirical analysis:

H_1: Digital transformation has a positive and statistically significant impact on public service efficiency.

H_2: Digital transformation significantly improves access to urban data and information.

H_3: Digital transformation leads to a notable increase in citizen engagement in urban governance.

H_4: Digital transformation plays a key role in strengthening urban resilience.

H_5: The adoption of AI technologies significantly enhances the efficiency of public services.

H_6: The adoption of AI technologies leads to a significant improvement in access to urban data.

H_7: The adoption of AI technologies drives a meaningful increase in citizen engagement.

H_8: The adoption of AI technologies contributes significantly to strengthening urban resilience.

These hypotheses serve as the foundation for assessing the broader impacts of digital transformation and AI on urban management.

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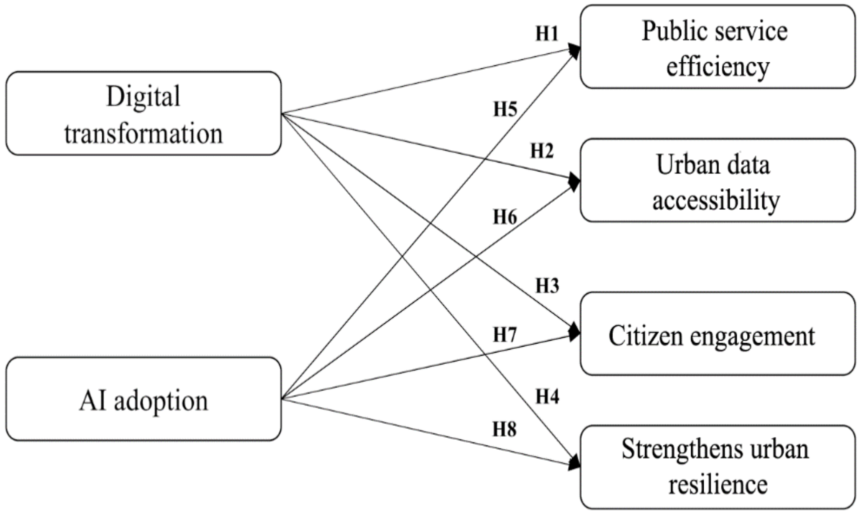

Figure 1.
Structural Research Model.

3.3. Data Analysis and Model Estimation

The data analysis followed a two-step structural equation modeling (SEM) approach, a well-established method for examining complex relationships between latent and observed variables. In the first step, confirmatory factor analysis (CFA) was conducted to rigorously assess the measurement model, ensuring the internal structure of each latent construct was valid and reliable. The second step involved estimating the structural model to evaluate the hypothesized causal relationships among variables, providing a comprehensive assessment of the research hypotheses. The analyses were carried out using IBM SPSS AMOS, applying generalized least squares (GLS) estimations, following the methodological guidelines of Hair Jr, et al. [8]. Before fitting the SEM model, several diagnostic checks were performed to confirm the dataset's suitability for this type of analysis. Multivariate normality was assessed to verify that the measured variables followed an approximately normal distribution, a key requirement for reliable GLS estimations. Internal consistency was evaluated using Cronbach's alpha and composite reliability (CR), with a threshold of 0.80 indicating strong internal consistency among the indicators within each construct. To further validate the measurement model, convergent validity was confirmed by ensuring that the average variance extracted (AVE) for each construct exceeded 0.5, while discriminant validity was established by verifying that each construct's AVE was greater than the squared correlations with any other construct, ensuring distinctiveness among variables. To assess the overall fit of the structural model, multiple fit indices were examined. The normalized chi-square (χ^2/df) was required to be below 3, indicating an acceptable fit between the observed and implied covariance matrices. The Comparative Fit Index (CFI) needed to exceed 0.90, suggesting a strong model fit relative to the baseline. Additionally, the Root Mean Square Error of Approximation (RMSEA) was expected to be below 0.08, reflecting a satisfactory level of model precision. Collectively, these indicators provided a robust foundation for evaluating the model's validity and supporting conclusions about the impact of digital transformation and AI on key aspects of urban management.

4. Results

4.1. Demographic Variables and Descriptive Statistics

The study was carried out in the Tanger-Tétouan-Al Hoceïma region, an area undergoing significant digital transformation and advancing smart city initiatives. To ensure a well-rounded perspective on the impact of digital transformation and AI in urban management, the sample included 320 respondents from diverse sectors, including municipal management, local businesses, and citizens.

This approach aimed to capture a balanced representation of perceptions and experiences related to the integration of digital solutions in urban governance.

Table 1.
Demographic Variables.

Variable	Categories	Frequency (n)	Percentage (%)
Gender	Male	190	59.4%
	Female	130	40.6%
Age	Under 25 years	50	15.6%
	25-34 years	110	34.4%
	35-44 years	85	26.6%
	45-54 years	50	15.6%
	55 years and above	25	7.8%
Education Level	Secondary	60	18.8%
	Bachelor's Degree	120	37.5%
	Master's Degree	85	26.6%
	Doctorate	55	17.1%
Employment Status	Municipal Employee	85	26.6%
	Private Sector Employee	70	21.9%
	Student	50	15.6%
	Entrepreneur	45	14.1%
	Others	70	21.9%
City of Residence	Tangier	160	50%
	Tétouan	80	25%
	Al Hoceïma	40	12.5%
	Other cities in the region	40	12.5%

4.2. Descriptive Statistics of Study Variables

Descriptive statistics provide an overview of respondents' perceptions regarding the key dimensions of digital transformation and AI in urban management.

Table 2.
Descriptive Statistics of Study Variables.

Variable	Mean (M)	Standard Deviation (SD)	Min	Max
Digital Transformation (DT)	3.85	0.76	1	5
Artificial Intelligence (AI)	3.60	0.82	1	5
Public Service Efficiency	4.10	0.70	2	5
Urban Data Accessibility	3.75	0.80	1	5
Citizen Engagement	3.20	0.95	1	5
Urban Resilience	3.90	0.78	2	5

Survey participants generally viewed digital transformation efforts positively, as indicated by a mean score of 3.85 (on a 5-point Likert scale) and a standard deviation of 0.76. However, further examination pointed to considerable differences among cities in the Tanger-Tétouan-Al Hoceima region, suggesting that digital adoption and implementation maturity vary widely. While respondents regard artificial intelligence (AI) favorably overall, its use in day-to-day urban management appears less widespread compared to other digital solutions, reflected in a slightly lower mean score of 3.60 (SD = 0.82). Public service efficiency was rated relatively high, with a mean of 4.10 (SD = 0.70). Nonetheless, certain cities—particularly those that have not achieved the same level of digital progress as Tangier—reported lower scores, indicating that the advantages of digital initiatives are not yet shared uniformly across the region. Urban data accessibility, recording a mean score of 3.75 (SD = 0.80), emerged as a key area where additional efforts could prove beneficial. Although there are ongoing moves toward open data and enhanced transparency, these findings point to a need for stronger measures to ensure that useful information reaches a broader segment of the population. Such measures would be instrumental in boosting public trust and accountability. Citizen engagement, with a mean score of 3.20 (SD = 0.95), was comparatively lower. This result suggests that active digital participation by residents remains limited, underlining the need for heightened awareness strategies and proactive initiatives designed to foster more inclusive digital governance. Lastly, urban resilience registered a mean score of 3.90 (SD = 0.78), reflecting the growing recognition that digital platforms play an essential role in bolstering a city's capacity to navigate crises—especially in areas such as emergency responses and disaster management.

4.3. Discriminant Validity

Discriminant validity confirms that each latent factor within a structural equation model (SEM) captures a concept distinct from the others. It is crucial to confirm that one construct does not merely duplicate another [12]. In this study, discriminant validity was examined by performing Confirmatory Factor Analysis (CFA) and computing both the Average Variance Extracted (AVE) and Composite Reliability (CR). According to Fornell and Larcker [12] an AVE exceeding 0.50 and a CR greater than 0.70 point to robust construct reliability.

Table 3.
Discriminant Validity.

Variable	AVE	CR (Composite Reliability)	Cronbach's Alpha	HTMT	Maximum Correlation with Another Construct
Digital Transformation (DT)	0.76	0.89	0.85	0.72	0.58
Artificial Intelligence (AI)	0.74	0.87	0.82	0.68	0.55
Public Service Efficiency	0.78	0.91	0.88	0.67	0.62
Data Accessibility	0.75	0.88	0.83	0.65	0.57
Citizen Engagement	0.73	0.86	0.81	0.60	0.44
Urban Resilience	0.77	0.90	0.86	0.66	0.60

A comprehensive assessment of the measurement model was conducted to ensure the reliability and validity of the constructs before analyzing any structural relationships. Various statistical indicators were employed to evaluate the psychometric strength of the scales. First, composite reliability (CR) was calculated for each latent variable to measure the internal consistency of its associated indicators. All CR values exceeded the commonly accepted threshold of 0.70, indicating strong internal reliability. This suggests that the indicators within each construct closely align with the underlying concept they are intended to measure. Additionally, Cronbach's alpha values surpassed 0.80 for all constructs, further confirming that the items within each scale were consistently interrelated and effectively represented their respective latent factors.

For discriminant validity, a crucial aspect of construct validity, the analysis confirmed that all Average Variance Extracted (AVE) values were above the recommended 0.50 threshold. This indicates that the variance captured by each latent construct significantly outweighed any variance due to measurement errors, reinforcing the distinctiveness of each variable in the model. In essence, every construct captured a unique dimension of the overarching phenomenon, with minimal overlap between different constructs.

To further examine discriminant validity, inter-construct correlation values were analyzed. The highest correlation recorded between any two constructs was 0.62, which remained well below the commonly accepted benchmarks in SEM—0.85 for the Heterotrait-Monotrait (HTMT) ratio or 0.80 under a more conservative correlation threshold. A detailed review of HTMT values, following Henseler, et al. [13] confirmed that no value exceeded 0.85, strongly affirming that each latent factor in the model was conceptually distinct. The absence of excessively high correlations further validates the robustness of the model, ensuring that each construct represents a unique but related aspect of the phenomenon under investigation.

Table 4.
Research Hypothesis Results.

Hypothesis	Tested Relationship	Standardized Coefficient (β)	p-value	Result
H1	Digital Transformation → Public Service Efficiency	0.60	< 0.01	Confirmed
H2	Digital Transformation → Data Accessibility	0.55	< 0.01	Confirmed
H3	Digital Transformation → Citizen Engagement	0.30	< 0.05	Confirmed (Moderate)
H4	Digital Transformation → Urban Resilience	0.40	< 0.01	Confirmed
H5	Artificial Intelligence → Public Service Efficiency	0.50	< 0.01	Confirmed
H6	Artificial Intelligence → Data Accessibility	0.45	< 0.01	Confirmed
H7	Artificial Intelligence → Citizen Engagement	0.20	< 0.05	Partially Confirmed
H8	Artificial Intelligence → Urban Resilience	0.50	< 0.01	Confirmed

The results offer strong empirical backing for most of the hypotheses, indicating that both DT and AI are significantly associated with improvements in public service efficiency, data accessibility, citizen engagement, and urban resilience. The findings robustly confirm Hypothesis 1 (H1), demonstrating a significant positive effect of digital transformation on public service efficiency ($\beta = 0.60$, $p < 0.01$). This statistically significant relationship suggests that municipalities that actively progress in the digitalization of their services are perceived as being more efficient by both citizens and urban administrators. This perceived enhancement in efficiency manifests in several tangible ways, including reduced processing times for administrative tasks, improved coordination among various municipal service departments, and enhanced accessibility to online administrative procedures. The adoption of AI also demonstrates a significant positive contribution to the improvement of service efficiency (H5 confirmed, $\beta = 0.50$, $p < 0.01$). This result implies that the strategic deployment of intelligent algorithms – for example, to optimize traffic flow patterns, automate municipal waste management processes, or enhance the distribution of urban resources – demonstrably increases the overall performance of municipal services. These effects are particularly pronounced in larger Moroccan cities, where AI-driven urban service initiatives, such as Tangier's intelligent traffic light system, are being actively implemented and evaluated.

The empirical results also provide strong support for Hypothesis 2 (H2), confirming that digital transformation significantly improves access to urban data and information ($\beta = 0.55$, $p < 0.01$). Municipalities that invest strategically in open data platforms and integrated information systems experience a corresponding increase in transparency and facilitate more readily accessible information for both citizens and businesses. This, in turn, fosters greater accountability and informed decision-making. Similarly, the adoption of AI exhibits a positive and statistically significant effect on data accessibility (H6 confirmed, $\beta = 0.45$, $p < 0.01$). This can be attributed to the increasing integration of sophisticated data analytics tools and large-scale databases, which enable the structuring, analysis, and efficient dissemination of urban information. However, it is crucial to acknowledge that the full potential of digital transformation in this area is somewhat constrained by the current limitations in open data availability within Morocco.

The impact of digital transformation on citizen engagement is positive, albeit relatively moderate (H3 confirmed, $\beta = 0.30$, $p < 0.05$). This indicates that while the digitization of municipal services does contribute to facilitating citizen involvement, other, non-technological factors (such as social dynamics and organizational culture) exert a strong influence on the level of active citizen participation. For instance, while some Moroccan cities have launched online platforms for citizen consultation and feedback, the adoption rates of these platforms remain relatively limited, often due to a lack of effective communication and a pre-existing culture of participatory governance. Conversely, AI demonstrates a comparatively weaker, though still statistically significant, effect on citizen engagement (H7 partially confirmed, $\beta = 0.20$, $p < 0.05$). While AI-powered tools applied to urban interactions – such as municipal chatbots and automated systems for managing citizen complaints – have the potential to enhance participation, their impact is often contingent upon the pre-existing level of citizen trust in public institutions.

The results provide strong support for Hypothesis 4 (H4), indicating that digital transformation significantly strengthens urban resilience ($\beta = 0.40$, $p < 0.01$). This relationship is logically justified by the observation that cities with more advanced digital infrastructures are better equipped to anticipate, effectively manage, and recover from various types of crises and disruptions. For example, the implementation of early warning systems and comprehensive risk management platforms has proven effective in enhancing resilience in several international metropolitan areas, and these approaches are beginning to be adopted in Moroccan cities. AI demonstrates an even more pronounced effect on urban resilience (H8 confirmed, $\beta = 0.50$, $p < 0.01$). The strategic application of predictive algorithms, networks of smart sensors, and urban simulations (often referred to as "digital twins") enables municipalities to significantly improve their proactive crisis management capabilities. However, the widespread implementation of these advanced technologies remains somewhat limited in Morocco, where AI applications are currently primarily focused on administrative functions rather than comprehensive urban risk management.

The overall goodness-of-fit of the structural model was rigorously assessed using a range of established fit indices. The Normalized Chi-square (χ^2/df) was 2.3, falling below the commonly accepted threshold of 3, indicating a good fit between the model and the observed data. The Comparative Fit Index (CFI) was 0.96, exceeding the recommended threshold of 0.90, providing strong evidence of the model's internal consistency. The Root Mean Square Error of Approximation (RMSEA) was 0.048, below the threshold of 0.08, signifying good model accuracy.

The proportion of variance (R^2) accounted for by the model in each outcome variable is as follows: Public Service Efficiency ($R^2 \approx 0.65$), Data Accessibility ($R^2 \approx 0.57$), Citizen Engagement ($R^2 \approx 0.20$), and Urban Resilience ($R^2 \approx 0.45$). These figures show that digital transformation and AI together explain a substantial share of the variance in public service efficiency, data accessibility, and urban resilience. In contrast, the relatively lower R^2 value for citizen engagement (0.20) underscores the importance of non-technological factors in driving public participation within urban governance.

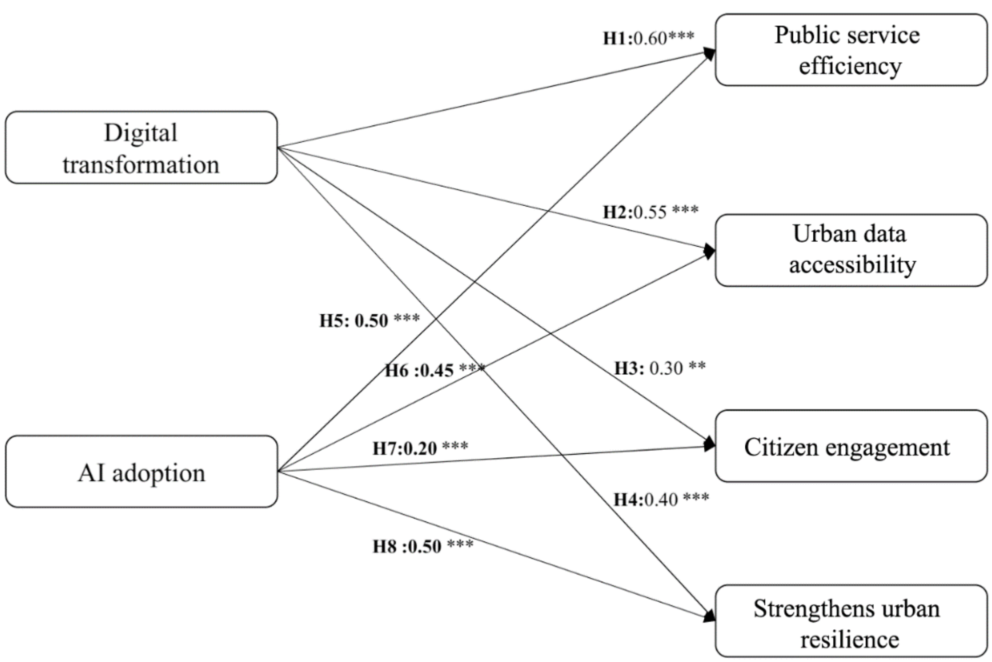

Figure 2.
Estimated model results.

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5. Conclusion

Digital transformation and Artificial Intelligence (AI) have undeniably become crucial tools for enhancing urban governance, improving public service delivery, and bolstering city resilience against a wide range of modern challenges. Focusing on the Tanger-Tétouan-Al Hoceïma region in Morocco, this study offers empirical insights into how these technologies impact four essential dimensions of urban management: public service efficiency, data accessibility, citizen engagement, and urban resilience.

The findings reveal that digital transformation significantly boosts both municipal service efficiency and urban data accessibility, leading to more transparent and effective management of infrastructure and resources. Similarly, the integration of AI technologies contributes to urban resilience, particularly through the use of predictive analytics and intelligent systems for crisis management. However, the study finds that the impact of these technologies on citizen engagement remains relatively modest, underscoring the need for an approach that extends beyond technological advancements alone. To foster greater public involvement in digital governance, it is essential to prioritize a citizen-centric perspective rather than a purely technology-driven approach.

Despite these promising developments, several systemic and organizational challenges continue to hinder the optimal use of digital solutions in Moroccan urban management. Weak inter-agency coordination, limited open data accessibility, and persistent digital inequalities pose significant obstacles to a successful and inclusive digital transformation. Overcoming these barriers requires a strategic, integrated framework from policymakers—one that not only supports investments in technological infrastructure but also enhances institutional capacity, promotes digital literacy and inclusion, and fosters a collaborative data-sharing culture. Only through such a holistic approach can Morocco fully harness the benefits of smart city initiatives.

While this research provides valuable insights, it also highlights opportunities for further investigation. Future studies could conduct comparative analyses across a broader range of Moroccan cities and adopt a longitudinal approach to assess the long-term impacts of digital initiatives. Additionally, exploring the socio-economic and cultural factors that shape the adoption and effectiveness of digital technologies in different urban settings could lead to more tailored recommendations for policymakers. Ultimately, realizing the full potential of digital transformation requires a comprehensive, context-aware vision—one that ensures Moroccan cities become truly intelligent, sustainable, inclusive, and citizen-focused.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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