

PRIMARY RESEARCH

Bridging the digital divide: The role of infrastructure, governance, and affordability in promoting digital engagement and socioeconomic development

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Digital Infrastructure
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This study investigates the impact of digital infrastructure investment, governance effectiveness, and affordability of digital access on the usage of digital services and socioeconomic development, while examining the mediating role of digital engagement in these relationships within the context of Pakistan's digital transformation. A quantitative research approach was adopted, and data were collected from 240 active digital service users in Pakistan using a structured questionnaire adapted from well-established scales. SmartPLS 4.0 was employed to assess the measurement and structural models through PLS-SEM, examining both direct and mediating effects. The results confirm that digital infrastructure investment, effective governance, and the affordability of digital access significantly enhance the use of digital services and positively contribute to socioeconomic development. Moreover, digital engagement emerged as a significant mediator, strengthening the influence of all three enabling factors on both digital usage and development outcomes. Governance effectiveness exhibited the strongest impact among all predictors. This study advances digital transformation literature by integrating technological, institutional, and economic enablers within a mediation-based behavioral framework. The findings provide strategic insights for policymakers to prioritize digital infrastructure, affordability, governance reforms, and user engagement initiatives to accelerate inclusive and sustainable digital development.

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INTRODUCTION

In the modern digital age, technological approaches to the economy and social life have become a decisive factor in sustainable development, inclusion, and national competitiveness. In developed and developing countries, governments and institutions have been devoting greater attention to digital transformation agendas to improve the delivery of public services, making them more efficient, accessible, and transparent. Digital platforms have become not only optional but also fundamental in driving

innovation, economic participation, and empowering society (Ahmed & Sur, 2023). The global trend towards digital economies is that e-governance programs, digital financial systems, online education programs, and online health services have been embraced to improve the quality of life and socioeconomic status of citizens (Hui et al., 2023). The growth of digital infrastructure, improved governance systems, and the affordability of digital are considered the pillars of this transformation process, as they will expand the reach of more people, facilitate equal participation,

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and spread technological change to underserved areas . Nevertheless, despite global advances, numerous countries still witness significant disparities in digital access, use, and the associated socioeconomic advantages, especially in lower-income and developing economies (C. Zhang et al., 2023). The differences presented in these disparities demonstrate the urgent need to comprehend how the enabling conditions, including infrastructure investment, the effectiveness of governance, and the affordability of digital access, determine digital engagement and, eventually, become the force behind the utilization of digital services and socioeconomic growth (Tian & Lu, 2023).

An increasing body of literature has defined the importance of digital infrastructure investment as the primary pillar of national digital transformation strategies. Scientists claim that funding for broadband connections, fiber-optic networks, and mobile communication systems enhances access to digital platforms and supports inclusive participation in economic activities (Ebele et al., 2023; Indriyarti et al., 2023; Wirtz et al., 2023). For example, in new economies, better infrastructure has been shown to increase the use of digital financial services, remote work, and access to educational and healthcare platforms (Soto Setzke et al., 2023). Likewise, research points to the equally important role of governance efficiency in promoting digital engagement, especially through transparent regulatory policies, user data security systems, and institutional trust, which can influence citizens to actively use government-led digital services (Abell & Biswas, 2023). It has been found that the higher the level of governance systems in countries, the higher the rate of digital use, because citizens trust digital choices and perceive institutional responsibility. Additionally, it has been discovered that the affordability of digital access is a determinant of digital inclusion. Reduced internet prices and digital access subsidies have greatly increased digital participation among disadvantaged groups, especially in rural regions, where limited financial means previously limited their use (Krysovatty et al., 2023). Research experiments in South Asia, Africa, and Latin America consistently show that the lower the barrier to digital access, the more individuals

adopt e-learning, e-commerce, telemedicine, and digital payment platforms (Brockhaus et al., 2022).

Digital engagement, as a behavioral construct in its own right, has already become a central concept, accounting for the extent to which people not only consume but also interact with and depend on digital services. The existing studies suggest that increased digital engagement leads to greater use of digital platforms, greater digital literacy, and better integration of digital tools into everyday life activities (Bakker et al., 2007). Notably, digital engagement has also been found to serve as an intervening variable in the relationship between enablers of digital access and tangible development. Scholars have shown that the quality of infrastructure, its affordability, and good governance are not the only factors that ensure digital adoption; people must also be motivated, skilled, and confident in using digital tools.

Nevertheless, there are some crucial gaps in the literature concerning the channels through which digital transformation leads to socioeconomic outcomes. To begin with, most prior literature has focused on the direct effect of digital infrastructure investment on digital adoption, without adequately accounting for the mediating behavioral processes that translate this investment into actual outcomes. Although infrastructure is generally recognized as an enabler, few studies have investigated how digital engagement serves as a bridging behavior that links infrastructure preparedness with the active use of digital services and consequent socioeconomic gains (Chen et al., 2023). Second, despite identifying governance effectiveness as an important institutional factor affecting the adoption of digital services, past research has tended to focus on the direct impact of governance, neglecting possible indirect effects via user behaviors, including trust, confidence, and interaction with digital systems (Tong & Chan, 2023). This implies that there are no detailed mediation-based models that integrate governance, engagement, and development outcomes within a single framework. Third, although affordability has been well-researched within the context of digital inclusion, available research typically does not explore the developmental outcomes of affordability beyond access and adoption. This lacks inves-

tigation into how affordability enables long-term digital activity and, eventually, leads to socioeconomic development, especially in low-income spaces where financial constraints severely limit digital access. Fourth, the literature has a geographical gap, with most research areas being developed or accelerating digitalisation, and relatively few investigations have been conducted in developing or transitioning economies that face complex infrastructural, economic, and policy barriers (Soto Setzke et al., 2023). Fifth, despite growing recognition of the mediating role of digital engagement, empirical studies remain scarce that clarify its particularity in transforming enabling environmental conditions into practical developmental outcomes. A large portion of the available literature assumes linear models with direct relationships, failing to recognize engagement as the central behavioral role in value realization (Fredricks et al., 2004). All these gaps together support the necessity of the current paper, which proposes a holistic perspective that emphasizes the importance of digital infrastructure investment, good governance, and the cost-effectiveness of digital infrastructure in improving the utilization of digital services and socioeconomic progress, with digital engagement as a mediating variable.

The main aim of the study is to investigate the effects of enablers, such as investment in digital infrastructure, governance, and the affordability of digital access, on the use of digital services and their role in socioeconomic development. The purpose of this study is to explore not only which of these enablers are directly related to development outcomes, but also why digital engagement is so important as an intermediate mechanism enabling this transformation. In particular, the research will evaluate the relationship between digital infrastructure investment and digital service adoption, thereby identifying the behavioral significance of user involvement in realizing the benefits of infrastructure development. In addition, the paper will investigate whether the effectiveness of governance can lead to improved socioeconomic outcomes by boosting levels of digital interaction and trust in digital systems. The other goal is to examine whether the affordability of digital access, beyond its contribution to basic access, encourages long-term digital participation and facilitates

engagement in digital economic activity that supports national development. The research also seeks to build and confirm an integrated conceptual framework grounded in existing theoretical frameworks to offer a systematic understanding of how inputs into digital transformation can be converted into effective outputs.

The research is extremely relevant to policymakers, digital strategists, and development practitioners aiming to improve digital inclusion and national development results in fast-digitalizing economies. This study offers an in-depth insight into the potential to transform digital transformation inputs into viable results using behavioral processes by incorporating all three components of technological, institutional, and economic enablers into a single model. The adoption of digital engagement as a mediating construct can provide useful insights into user-centric digital policymaking, where motivation, awareness, and active engagement are the main aspects. The research conclusions will inform the design of evidence-based digital strategies to ensure fair access, foster economic growth, and promote social inclusion.

The theoretical basis of the presented research is primarily the Technology-Organization-Environment (TOE) model and Diffusion of Innovation (DOI) theory, which provide in-depth insights into the nature of digital transformation within societal systems. The TOE framework Oliveira and Martins (2011) assumes that the adoption of innovation depends on technological readiness, institutional stimulus, and the accessibility of environmental factors. Digital infrastructure investment represents the technological aspect in this context; the effectiveness of governance reflects the organizational and institutional environment; and providing digital access represents environmental inclusiveness, enabling the masses to adopt it. In line with this, Rogers' Diffusion of Innovation theory highlights that perceived benefits, social systems, and communication structures are the leading factors influencing innovation adoption, all of which are directly connected to digital engagement as a measure of how people internalize and actively engage with digital ecosystems. All these theories support the postulated mediating role of digital engagement because users need to feel, be, and remain

constantly in contact with the digital platform so that conditions under infrastructure, governance, and affordability are improved.

LITERATURE REVIEW

Affordability of Digital Access, Digital Infrastructure Investment, Governance Effectiveness, and Usage of Digital Services

Digital infrastructure investment is the allocation of resources to expand and modernize the technological infrastructure needed to ensure a seamless digital connection and service delivery (Tian & Lu, 2023). This encompasses broadband networks, mobile communication, fiber-optic networks, and data processing plants through which individuals, businesses, and institutions access and use digital platforms effectively. The use of digital services, on the other hand, refers to the degree to which individuals and institutions actively use digital media to access e-governance, financial services, education, healthcare, e-commerce, and other online services (Koskelainen et al., 2023). Previous studies have shown that sufficient digital infrastructure is critical for reducing network delays, improving accessibility, and enhancing the reliability of digital systems. Research and literature on the evolution of developing countries show that the greater the infrastructure investments in any region, the higher the rate of adopting digital payment systems, e-government portals, and online provision of government services. The higher the quality of infrastructure, the greater users' confidence in the efficiency and availability of digital solutions, which increases their interaction with digital ecosystems. This solid piece of evidence supports the argument that digital infrastructure investment is a preliminary facilitator of digital service consumption, indicating that investment activities trigger technological accessibility and the feasibility of utilization among citizens. Thus, the study's hypothesis is that digital infrastructure investment positively affects the use of digital services (Hu et al., 2023).

Governance effectiveness is the ability of government institutions to implement effective policies, ensure transparency, establish regulatory frameworks, and deliver public services effectively through digital channels (Masyk et

al., 2023). It covers aspects that include policy delivery, institutional trust, corruption prevention, and sensitivity to societal needs (Nguyen & Dang, 2023). According to the available literature, citizens would be more willing to trust and follow government-led digital systems, including e-taxation, e-procurement, and digital documentation portals, when they see that governance systems are competent and accountable. Empirical evidence also suggests that governance quality is a robust predictor of digital transformation success, as high governance effectiveness in countries can prompt swift adoption of government digital services, driven by increased perceptions of reliability and security. Studies in developed and developing settings demonstrate that citizens tend to use digital platforms more often when they are convinced that government institutions will preserve their data, guarantee the integrity of systems, and provide them with efficient service delivery (Banik et al., 2023; Dossou et al., 2023; Y. Zhang et al., 2023). These factors support the notion that effective governance creates an enabling environment for digital engagement. Based on these empirical findings, it is hypothesized that governance effectiveness positively affects the use of digital services.

Affordability of digital access is the degree to which people can access digital access services, including internet subscriptions, mobile data plans, and technology gadgets, without being financially burdened by their cost. This dimension is very important for eliminating the digital divide, especially among low- and middle-income groups, where digital sensitivity is a significant obstacle to digital adoption. Various empirical studies have shown that reducing internet costs increases adoption of digital platforms, especially among underserved and rural populations. The concept of affordability has been shown to directly influence the use and diversification of digital services, enabling users to engage in activities such as e-learning, e-banking, and telemedicine (Al-Smadi, 2023). Previous studies prove that once access to digital becomes economically cost-effective, users form long-lasting engagement patterns, proving to be the contributors to the performance of digital literacy, as well as increased dependence on digital services to meet their daily needs (Wirtz

et al., 2023). This accumulating literature indicates that affordability is an important driver of greater digital participation. Therefore, the hypothesis is that the affordability of digital access has a positive impact on the utilization of digital services.

H1a: Digital infrastructure investment positively influences the usage of digital services.

H1b: Governance effectiveness positively influences the usage of digital services..

H1c: Affordability of digital access positively influences the usage of digital services.

Affordability of Digital Access, Digital Infrastructure Investment, Governance Effectiveness, and Socioeconomic Development

Socioeconomic development can be defined as the process by which there are positive changes in the well-being, economic status, and quality of life of the people and the communities (Adebayo & Ullah, 2023). It includes indicators of income growth, employment, access to education, access to healthcare, social inclusion, and overall human development (C. Zhang et al., 2023). Socioeconomic growth is deeply interconnected with people's ability to engage productively in the digital economy, access basic services, and enjoy improved connectivity and information exchange. It has been increasingly acknowledged that the spread of digital technologies can serve as a potent catalyst for socioeconomic development, facilitating innovation and entrepreneurship, as well as inclusive growth. According to previous literature, digital transformation is essential for improving government service delivery to the population, reducing disparities, and boosting countries' economic competitiveness (Theokritoff et al., 2023).

Empirical studies available indicate that investment in digital infrastructure is a significant boost to socioeconomic development, as it provides access to education, digital financial systems, healthcare services, and employment opportunities (Banik et al., 2023; Masyk et al., 2023; Ülev et al., 2022). Research conducted in Asia, Africa, and Latin America demonstrates that nations with high investment in digital infrastructure experience stronger economic growth, lower poverty rates, and higher labour

productivity in both urban and rural areas. Equally, the effectiveness of governance has been observed to boost socioeconomic development through transparent policy-making, effective distribution of state resources, and enhanced digital service delivery. Studies also emphasize that, where governance systems are proper, reputable, and technologically responsive, citizens are more likely to enjoy the benefits of digital reform and welfare initiatives (Hu et al., 2023). Moreover, a few studies have determined that the affordability of access to digital technologies is the key element of inclusive socioeconomic development because affordable access reduces the barriers to digital education, entrepreneurship, and the labor market among disadvantaged groups (Brockhaus et al., 2022; Tang & Yang, 2023).

Based on the existing body of empirical evidence, one can posit that digital infrastructure investment is a beneficial factor in socioeconomic development, as it facilitates digital inclusion, economic engagement, and access to quality-of-life services. Similarly, the effectiveness of governance is expected to positively impact socioeconomic development by ensuring the effective implementation of digital policies and making state-led development initiatives more equitable. Moreover, when digital access is affordable, people in lower-income groups can participate in digital economies, thereby increasing their economic capacity and social mobility (Velis et al., 2023). Considering these empirical findings, the hypothesis is that digital infrastructure investment, effective governance, and the affordability of digital access have a positive impact on socioeconomic development.

H2a: Digital infrastructure investment positively influences socioeconomic development.

H2b: Governance effectiveness positively influences socioeconomic development.

H2c: Affordability of digital access positively influences socioeconomic development.

Digital Engagement as Mediator

Digital engagement refers to the level of active use, interaction, and continued use of digital services by people, including e-government services, online financial systems,

education portals, and social services. It is not only a matter of access but also of habitual and meaningful use, driven by motivation, digital literacy, and perceived usefulness. Empirical research has shown that digital infrastructure alone is insufficient to ensure the use of digital services without active user engagement with digital technologies. For example, it has been established that the expansion of broadband and mobile networks will only lead to growth in digital participation when people demonstrate readiness to explore, adopt, and continually apply digital applications. Equally, research indicates that effective governance increases trust and confidence among the people and therefore enhances more active digital engagement rather than just accessibility. In the context of affordability, the evidence indicates that lowering the cost of digital access will prompt underserved communities to experiment with and embrace digital platforms, leading to more robust digital engagement practices before they engage with the actual services. Such results show that digital engagement tends to be an intermediate behavioral feature, in which enabling factors (including infrastructure, governance, and affordability) are translated into real-world use of digital services.

Based on these empirical grounds, it is possible to state that the relationship between digital infrastructure investment and the effectiveness of governance, the affordability of digital access, and the use of digital services is mediated by digital engagement. The higher the standard of the infrastructure, the more active users will be due to increased speed and enhanced service stability, and the level of digital consumption. In a similar manner, when governance systems are accountable and efficient, the heavy use of digital platforms can be demonstrated by higher levels of user confidence and trust, which subsequently stimulate greater use of these platforms. Regarding affordability, the availability of affordable digital access would foster more interactions among people who were previously left out, as they would be more inclined to embrace digital services. Thus, it has been hypothesized that digital engagement acts as an enabling factor, strengthening the pathway between enabling environmental factors and greater use of digital services, thereby supporting

the hypothesis that digital engagement mediates these relationships.

H3a: Digital engagement mediates the relationship between digital infrastructure investment and usage of digital services.

H3b: Digital engagement mediates the relationship between governance effectiveness and usage of digital services.

H3c: Digital engagement mediates the relationship between affordability of digital access and usage of digital services.

Empirical evidence from digital development studies has repeatedly demonstrated that investment in digital infrastructure is neither a contributor to socioeconomic outcomes in itself, but rather through the degree of public digital interaction that the infrastructure, which engages it, facilitates. Evidence from new economy countries shows that expanding infrastructure facilitates access to digitization, and that access to digitization can only be turned into socioeconomic value by active users of digital platforms, including better employability, entrepreneurship, and access to education and health services (Hu et al., 2023). Recent results from large-scale ICT adoption models continue to show that robust infrastructure is an important factor in improving digital participation patterns, which, in turn, lead to higher income prospects, greater productivity, and greater social inclusion. In the same line, it has been demonstrated that a better performance in governance improves the results of socioeconomic development by increasing digital trust and participation because citizens will tend to use digital welfare services, financial inclusion programs, and e-participation systems when they believe that the governance systems are customer-oriented and effective (Abell & Biswas, 2023). According to these studies, the digital transformation projects in which governance plays a leading role can lead to greater socioeconomic gains, should they lead to an increase in digital levels of engagement by users (Ahmad & Bajwa, 2023; Jie et al., 2023).

Moreover, empirical data in the literature on digital affordability indicate that lower levels of economic obstacles to digital access increase the likelihood of active engagement

between marginalized and rural populations, which subsequently leads to access to digital marketplaces, remote work, and developmental mechanisms (Khan et al., 2023). Research on the inclusive digital economy shows that affordability enables adoption and engagement, which can subsequently lead to higher income levels, greater knowledge acquisition, and improved quality-of-life outcomes (C. Zhang et al., 2023). All these findings seem to indicate that digital engagement is an essential behavioral process that infrastructural and governance affordances can be converted into the wider socioeconomic developments (Tong & Chan, 2023). Thus, it is rationally supported that the interaction between digital infrastructure investment and socioeconomic development, governance effectiveness, and the affordability of digital access is mediated by digital engagement.

H4a: Digital engagement mediates the relationship between digital infrastructure investment and socioeconomic development.

H4b: Digital engagement mediates the relationship between governance effectiveness and socioeconomic development.

H4c: Digital engagement mediates the relationship be-

tween the affordability of digital access and socioeconomic development.

Theoretical Framework Supporting the Research

The connections described in the study can be theoretically grounded in the Technology-Organization-Environment (TOE) model and the Diffusion of Innovations (DOI) theory, which can thoroughly explain the process of digital transformation that leads to service adoption and socioeconomic growth. Oliveira and Martins (2011) proposed the TOE framework, which is based on the assumption that three contexts, namely, the technological (digital infrastructure and accessibility), organizational or institutional (governance effectiveness), and environmental (socioeconomic and affordability conditions), determine the adoption and diffusion of technological innovations. Digital infrastructure investment in this paper is seen as the technological facilitator that promotes connectivity, access, and governance effectiveness, which in turn builds institutional preparedness that fosters trust and policy support, and affordability of digital access exemplifies environmental inclusivity, enabling large numbers of people to participate.

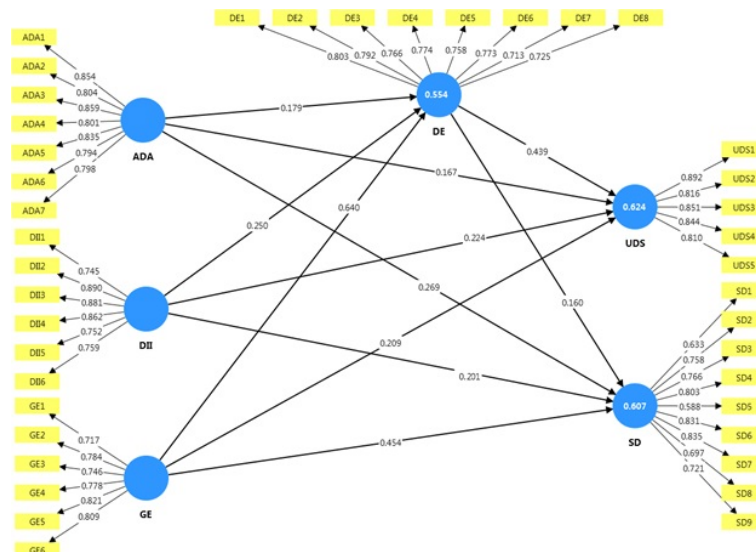


FIGURE 1. Conceptual framework

In line with this, the Diffusion of Innovation theory proposed by Rogers (2009) holds that perceptions of benefits, social systems, and communication channels are com-

plementary factors that influence digital adoption rates and levels, as indicated by digital engagement behaviours. Digital engagement is therefore a behavioral model that

converts structural and institutional facilitators into application performance outcomes, such as the use of digital services and broader socioeconomic gains. Earlier empirical studies indicate that theoretical integration with strong infrastructure, good governance, and low access costs enables ecosystems that drive digital engagement, which, in turn, drives digital adoption and development outcomes. In this regard, Figure 1 depicts a hypothetical model in which digital infrastructure investment, governance effectiveness, and the affordability of digital access can have direct and indirect effects on the use of digital services and socioeconomic development, mediated by digital engagement.

METHODOLOGY

The research design followed in this paper was a quantitative approach that empirically tested the relationships between digital infrastructure investment and governance effectiveness, the affordability of digital access, digital engagement, the use of digital services, and socioeconomic development. The structured survey questionnaire was the primary data collection instrument and is considered a suitable tool for research on technology adoption when analyzing behavioral and latent constructs are required (Hair & Alamer, 2022). The survey was conducted on 240 active digital service users in Pakistan, who use digital governance websites, online banking, e-learning websites, and utility-based online applications. The purposive sampling strategy was employed to ensure that the respondents had previously been exposed to digital platforms and, as such, were the right ones to be included in the study. The sample size exceeded the minimum requirements for PLS-SEM analysis and satisfied the 10-times criterion for structural path complexity (Hair Jr et al., 2021). The questionnaire also included well-established, validated scales from the previous literature. The measures used to assess digital infrastructure investment were based on adaptation of items, governance effectiveness from (Kaufmann et al., 2010), affordability of digital access from digital engagement Venkatesh et al. (2012), usage

of digital services Carter and Bélanger (2005), and socioeconomic development Niebel (2018) and UNDP human development frameworks. Then all items were measured on a five-point Likert scale: 1 = strongly disagree, 2 = moderately disagree, 3 = moderately agree, 4 = strongly agree, and 5 = strongly agree. The instrument was tested by academic experts in a pilot study before full-scale data collection to ensure clarity, content adequacy, and context suitability. The questionnaire's consistency was ensured because all constructs had Cronbach's alphas and composite reliabilities greater than 0.70, the recommended value. Convergent validity was established based on Average Variance Extracted (AVE) values above 0.50, and discriminant validity was established using the HTMT ratio, which ensures the individuality of each construct.

SmartPLS 4.0 was used to analyze the data, following the traditional two-step PLS-SEM procedure. The measurement model was evaluated in the first step for reliability (internal consistency), convergent validity, and discriminant validity. The second step involved evaluating the structural model by testing the hypothesized relationships using bootstrapping with 5,000 resamples. Path coefficients, t-statistics, and p-values were investigated to find the significance of direct and mediating effects. Also, the R-square and Q-square values were checked to assess the model's predictive and explanatory power. The findings showed that the theoretical and statistical strength of the proposed relationships is high in Pakistan's current, fast-evolving digital transformation environment.

RESULTS

Table 1 and Figure 2 show that all constructs demonstrate strong reliability and convergent validity. Each construct exceeds the minimum recommended threshold of 0.70 for Cronbach's alpha and composite reliability Fornell and Larcker (1981), confirming internal consistency. Affordability of digital access reports a Cronbach's alpha of 0.920 and a CR of 0.935, while its AVE of 0.674 confirms convergent validity, as it exceeds the 0.50 benchmark suggested by (Hair Jr et al., 2021).

TABLE 1. Variables reliability and validity

	Items	Outer Loading	Cronbach's alpha	CR	AVE
Affordability of Digital Access	ADA1	0.854	0.920	0.935	0.674
	ADA2	0.804			
	ADA3	0.859			
	ADA4	0.801			
	ADA5	0.835			
	ADA6	0.794			
	ADA7	0.798			
Digital Engagement	DE1	0.803	0.898	0.918	0.583
	DE2	0.792			
	DE3	0.766			
	DE4	0.774			
	DE5	0.758			
	DE6	0.773			
	DE7	0.713			
	DE8	0.725			
Digital Infrastructure Investment	DII1	0.745	0.899	0.923	0.668
	DII2	0.890			
	DII3	0.881			
	DII4	0.862			
	DII5	0.752			
	DII6	0.759			
Governance Effectiveness	GE1	0.717	0.868	0.901	0.603
	GE2	0.784			
	GE3	0.746			
	GE4	0.778			
	GE5	0.821			
	GE6	0.809			
Socioeconomic Development	SD1	0.633	0.895	0.916	0.549
	SD2	0.758			
	SD3	0.766			
	SD4	0.803			
	SD5	0.588			
	SD6	0.831			
	SD7	0.835			
	SD8	0.697			
	SD9	0.721			
Usage of Digital Services	UDS1	0.892	0.898	0.925	0.711
	UDS2	0.816			
	UDS3	0.851			
	UDS4	0.844			
	UDS5	0.810			

Digital engagement also demonstrates satisfactory psychometric properties, with an alpha of 0.898, a CR of 0.918, and an AVE of 0.583. All outer loadings across constructs exceed the acceptable 0.70 threshold for most indicators, signifying strong indicator reliability. Investment in digital infrastructure, effectiveness of governance, and socioeconomic development are quite significantly higher than the reliability and AVE standards, which means clearly defined metrics. The top outer loading (0.892) and high AVE (0.711) are associated with the usage of digital services. The overall findings support the conclusion that each measurement construct demonstrates adequate internal consistency and convergent validity, which is critical for robustness in PLS-SEM measurement models.

Table 2 indicates that the model presents an acceptable ex-

planatory power and predictive relevance. The *R*-squared values for digital engagement (0.554), socioeconomic development (0.607), and the use of digital services (0.624) indicate strong explanatory power, based on Cohen (1998) thresholds. Adjusted *R*-squares are slightly lower but remain consistent, supporting the model's stability. The predicted *Q* 2 values are greater than 0, confirming the model's medium to strong predictive relevance (Hair Jr et al., 2021). Also, SRMR is 0.080, well below the recommended maximum of 0.10, suggesting good overall model fit. The RMSE and MAE values are also within acceptable limits, indicating that the model has strong predictive power across variables. All these findings confirm that the structural model has high explanatory and predictive adequacy (Chin, 1998).

TABLE 2. *R*² statistics model goodness of fit statistics

	<i>R</i> ²	<i>R</i> ² adjusted	<i>Q</i> ² predict	RMSE	MAE	SRMR
Digital Engagement	0.554	0.548	0.462	0.742	0.582	0.080
Socioeconomic Development	0.607	0.601	0.580	0.657	0.492	
Usage of Digital Services	0.624	0.620	0.609	0.631	0.490	

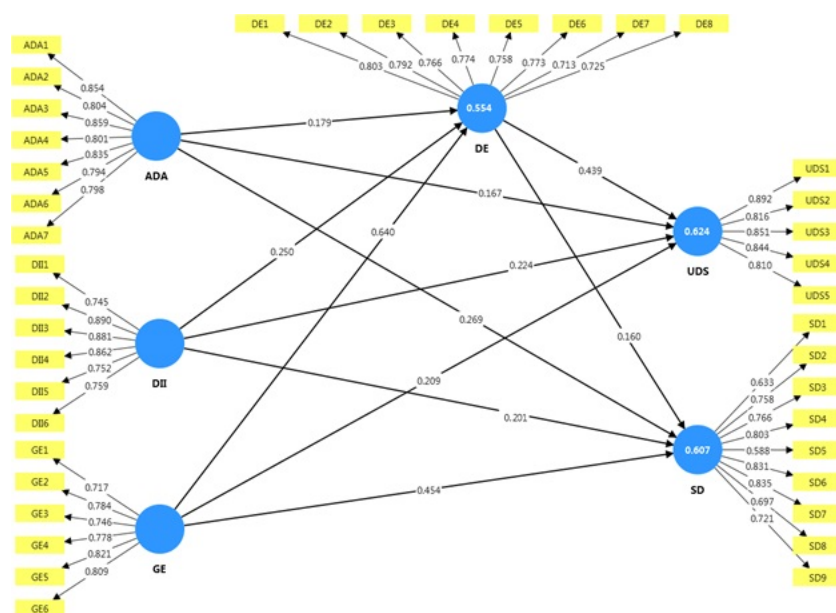


FIGURE 2. Structural model

Table 3 presents the results of the structural model analysis, confirming that all hypothesized relationships are statistically significant and positive. The first group of

hypotheses (H1a–H1c) demonstrates that digital infrastructure investment, governance effectiveness, and affordability of digital access each significantly enhance the

usage of digital services. Specifically, digital infrastructure investment shows a positive path coefficient ($\beta = 0.224$, $t = 2.331$, $p = 0.007$), indicating that improved network connectivity, broadband expansion, and technological accessibility substantially increase user participation in digital platforms. Governance effectiveness also has a significant effect ($\beta = 0.209$, $t = 2.500$, $p = 0.006$), signifying that transparent governance systems and trustworthy institutional mechanisms promote user confidence and stimulate engagement with e-government and other online services. Similarly, the affordability of digital access significantly influences digital service adoption ($\beta = 0.167$, $t = 2.431$, $p = 0.008$), suggesting that lower costs and inclusive pricing models are key motivators for digital participation among diverse socioeconomic groups. The second group of hypotheses (H2a–H2c) also finds strong support, with digital infrastructure investment ($\beta = 0.201$, $t = 2.013$, $p = 0.009$), governance effectiveness ($\beta = 0.454$, $t = 7.275$, $p = 0.000$), and affordability of digital access ($\beta = 0.269$, $t = 4.097$, $p = 0.000$) all exerting positive and significant impacts on socioeconomic development. These results indicate that technological readiness, institutional efficiency, and economic accessibility collectively foster employment opportunities, social inclusion, and sustainable growth, reinforcing prior evidence that digital transformation is a cornerstone of national development.

The third and fourth sets of hypotheses (H3a–H3c and H4a–H4c) further confirm that digital engagement plays a

significant mediating role in these relationships. The mediation between governance effectiveness and the use of digital services is particularly strong ($\beta = 0.281$, $t = 4.651$, $p = 0.000$), indicating that effective governance enhances citizens' digital trust and motivation, which, in turn, increases their use of digital platforms. Similarly, digital engagement mediates the impact of digital infrastructure investment ($\beta = 0.072$, $t = 1.805$, $p = 0.010$) and affordability of digital access ($\beta = 0.078$, $t = 2.876$, $p = 0.002$) on digital service adoption, suggesting that infrastructural and economic enablers influence behavior through user interaction and sustained engagement. Moreover, the mediating role of digital engagement also extends to socioeconomic development outcomes, with significant indirect effects observed for digital infrastructure ($\beta = 0.108$, $t = 2.737$, $p = 0.031$), governance effectiveness ($\beta = 0.103$, $t = 2.351$, $p = 0.009$), and affordability ($\beta = 0.029$, $t = 1.963$, $p = 0.025$). These findings emphasize that engagement is the behavioral link that converts structural readiness into tangible developmental outcomes. Overall, the results of Table 4 provide comprehensive support for the proposed model, revealing that digital access, governance quality, and infrastructure must be complemented by active user engagement to produce measurable digital usage and socioeconomic progress, a finding that aligns with prior theoretical perspectives emphasizing the central role of human participation in the digital transformation process.

TABLE 3. Path analysis

H1a: Digital infrastructure investment positively influences usage of digital services.	0.224	0.071	2.331	0.007
H1b: Governance effectiveness positively influences usage of digital services.	0.209	0.083	2.500	0.006
H1c: Affordability of digital access positively influences usage of digital services.	0.167	0.069	2.431	0.008
H2a: Digital infrastructure investment positively influences socioeconomic development.	0.201	0.070	2.013	0.009
H2b: Governance effectiveness positively influences socioeconomic development.	0.454	0.062	7.275	0.000
H2c: Affordability of digital access positively influences socioeconomic development.	0.269	0.066	4.097	0.000

Path analysis

H3a: Digital engagement mediates the relationship between digital infrastructure investment and usage of digital services.	0.072	0.028	1.805	0.010
H3b: Digital engagement mediates the relationship between governance effectiveness and usage of digital services.	0.281	0.060	4.651	0.000
H3c: Digital engagement mediates the relationship between affordability of digital access and usage of digital services.	0.078	0.027	2.876	0.002
H4a: Digital engagement mediates the relationship between digital infrastructure investment and socioeconomic development.	0.108	0.011	2.737	0.031
H4b: Digital engagement mediates the relationship between governance effectiveness and socioeconomic development.	0.103	0.044	2.351	0.009
H4c: Digital engagement mediates the relationship between affordability of digital access and socioeconomic development.	0.029	0.015	1.963	0.025

DISCUSSION

The advent of the digital world has reshaped countries' development paths, becoming a supportive utility and then the key to the development of the economy, society, and institutions. In this regard, understanding the workings of the digital ecosystem and, more importantly, how people meaningfully engage with it is now an acute necessity for policymakers and researchers. This article contributes to that valuable discussion because it examines how the enabling factors central, which encompass the investment into digital infrastructure, efficiency of governance, and affordability of access to digital devices, transform into tangible product behaviors and national development. Instead of limiting the inquiry to direct relationships, the study is expanding the discussion by highlighting the behavioral role of online interaction as the process through which technological readiness, institutional trust, and economic accessibility translate into sustained online adoption and socioeconomic development. The discussion below speculates on the implications of the accepted hypotheses, places the findings in the context of the existing literature, and provides insight into multifaceted pathways through which digital transformation drives national growth.

The results of the present study support the claim that digital infrastructure investment, the effectiveness of governance, and the affordability of digital access play a significant role in the rise in the use of digital services. The adoption of H1a shows that investment in digital infrastructure becomes a facilitative enabler that fosters effortless connectivity, enhances network availability, as well as the ease of access to the digital platforms, and thus prompts people to engage actively in the usage of e-government, e-finance, e-learning, and other digital services (Wirtz et al., 2023). This observation aligns with the body of available literature, which has reaffirmed that effective technological infrastructure is a prerequisite for the rise in digital adoption and citizen use of digital ecosystems. The H-1B acceptance also underscores that government efficiency is a key factor shaping user confidence and institutional trust in digital services, leading to greater adoption and use. These findings align with other empirical studies demonstrating that open policies, strong digital governance institutions, and robust regulatory bodies tend to encourage the population to use open digital services (Turillazzi et al., 2023). In addition, the 'it-is-not-true' of H1c emphasises that the affordability of digital access has a major

impact on reducing economic barriers and permits the inclusion of a broad range of socioeconomic populations and the expansion of the digital user base to include previously underserved populations. This adds to the debate that the cost-effective access will ensure the amplified digital engagement and the growing frequency and diversity of digital activities. When combined, these results indicate that access to technology, institutional trust, and economic access are synergistic in promoting digital inclusion, and that a multidimensional approach is required to accelerate digital adoption in developing economies.

In addition to the impact on the digital service use, the findings confirm the positive influence of the digital infrastructure investment, the efficiency of digital governance, and the cost of digital access on socioeconomic development, as the acceptance of H2a, H2b, and H2c confirms. The H2a adoption proves that high-tech digital infrastructure is not only helpful for connectivity but also enables people to access digital jobs, financial services, distance education, and health services, thereby enhancing human capital and driving economic growth. These results align with earlier studies that linked digital infrastructure to high national productivity, innovation levels, and social inclusion (Tang & Yang, 2023). The fact that H2b has been accepted also underscores the role of good governance in promoting equal service delivery in the public sector, transparency, and accountability, thereby enabling citizens to access welfare schemes, financial aid systems, and development programs through viable digital platforms. This finding asserts that effective institutional frameworks can serve as a catalyst for digital-based growth and resource distribution. Lastly, H2c is accepted, which implies that affordability is a crucial factor in ensuring that citizens, especially low-income populations and marginalized groups, can obtain and consistently access digital services to improve their livelihoods, competencies, and financial opportunities (Hu et al., 2023). All these results underscore the revolutionary role of digital access, institutional governance, and technological preparedness in shaping the outcomes of national development. They underscore the importance of infrastructure development, governance reforms, and affordability policies in creating inclusive,

digital-based socioeconomic development.

The acceptance of H3a, H3b, and H3c is a compelling statement indicating that digital engagement effectively mediates the relationship between facilitating environmental variables and the actual use of digital services. H3a is accepted as demonstrating that, in the case of a major investment in digital infrastructure, the effect on service adoption is more pronounced when people actively use it. This aligns with the recognition that infrastructure availability cannot be adequate unless people have the motivation, awareness, and willingness to use the available technological resources. Similarly, the acceptance of H3b also supports the claim that effective governance will enhance user engagement, as people will be more willing to use the digital platform when institutional transparency, accountability, and data security are in place. This highlights the point that trust and institutional legitimacy are crucial behavioral forces that shape the quality of governance in digital participation. The fact that H3c is accepted means it is cheap to be digital, as it encourages users to develop meaningful, use-based habits due to lower financial expenditures. This result aligns with prior findings suggesting that low-cost digital access encourages individuals, particularly those in underserved groups, to become familiar with and actively use online services, ultimately influencing overall online service use. All these findings underscore the importance of digital engagement as a behavioral mediator that can transform infrastructural readiness, governmental trust, and economic affordability into material outcomes of digital adoption.

Moreover, the acceptance of H4a, H4b, and H4c reinforces the research argument that digital engagement is a fundamental mediating variable in transforming digital enablers into socioeconomic development. The acceptance of H4a suggests that electronic communication has a considerable positive effect on the level of structural development of investing in infrastructure by allowing individuals to access economic opportunities, education, healthcare, and public services through the use of digital platforms, hence turning technical availability into a significant social and economic advancement. On the same note, the acceptance of H4b indicates that the effectiveness of gov-

ernance plays a greater role in socioeconomic development, provided that citizens are actively involved in digital systems through digital platforms to access welfare schemes, financial resources, and skill-improvement programs. This shows that user participation is crucial for realizing governance-led digital reforms as developmental outcomes (Brockhaus et al., 2022). The fact that H4c is acceptable also demonstrates that affordability facilitates socioeconomic development along the digital engagement pathway, as affordable digital services enable marginalized groups to expand their livelihoods and social mobility by engaging in the digital economy.

Together, the confirmation of all four groups of hypotheses constitutes a complete and strong account: a digital transformation is most influential when interventions in technology investments, governance, and economic accessibility are combined and supported by significant user interaction. The results demonstrate that, despite the independent impact of the three elements of digital infrastructure, the efficacy of governance, and cost-effectiveness, these outcomes can be realized when citizens become involved and integrate digital technologies into their lives. This is evidence that online activity is not an incidental result of online preparedness, but is the driver that generates a digital impression. The paper is therefore an effective contribution to the theoretical and practical aspects of the matter, in which digital policy makers should focus beyond infrastructure and access by prioritizing behavioral activation methods that promote digital literacy, trust, inclusiveness, and sustained user interactions. Such an integrated approach is needed to translate digital potential into sustainable, inclusive, and measurable national development.

Implications

Theoretical implications

The research has enhanced the theoretical contribution to digital transformation research by supplementing the literature with a model that synthesizes the Technology Organization Environment (TOE) and Diffusion Of Innovation (DOI) frameworks and theories. This paper demonstrates that the digital transformation is not completely

dictated by the infrastructural, institutional, or economic conditions, and that it relies on the actions of the users, how they are motivated, and participate in the process extensively, which makes the position of the mediator, the digital engagement, a proven and tested idea. The results transcend the traditional linear model that treats digital engagement as the behavioral driver that converts enabling environmental conditions into measurable outcomes, such as the use of digital services and socioeconomic development. The fact is that this observation contributes to the theory of innovation adoption by highlighting that psychological readiness and experiential involvement are the two inseparable middle stages in the digital value chain. Moreover, this work confirms the TOE framework's assumption that technological, organizational, and environmental factors coexist and converge systematically to yield efficient innovation outcomes. It also fills an important conceptual void in the literature on digital development by demonstrating that digital infrastructure, governance quality, and affordability have the greatest impact when considered collectively within a framework of mediation rather than separately. In conclusion, the research relates to the body of knowledge on digital transformation theory, as it is more people-centered and engagement-based, and may stimulate further studies that examine the behavioral dynamics of digital policies and innovation models.

Practical implications

This study has practical implications for governments, policy-makers, digital strategists, and development agencies interested in rapid, inclusive digital change. The conclusion is evident: the policy issues of digital infrastructure and affordability must be addressed, but not limited to that alone, unless there are actions to encourage the active use of digital infrastructure by users. It implies that digital transformation plans should focus not only on introducing new hardware and reducing costs, but also on digital literacy training, user experience enhancements, trust-building through communication, and the implementation of behavioral change campaigns. Reforms to the governance system are more focused on enhancing trans-

parency, credibility, and data security, as these factors would increase public confidence and significantly boost digital attendance. Additionally, the affordability role highlights the importance of making access subsidized, free, and directly offered to underserved populations to close the digital divide. Since digital engagement is the most influential behavioral determinant of technological preparedness and developmental performance, governments should initiate programs that not only enable access but also promote long-term, high-level use of digital services across education, finance, healthcare, and e-governance. Finally, the study offers a roadmap for developing digital transformation policies that are inclusive, user-centered, and development-focused, so that digital transformation can be translated into long-term socioeconomic benefits.

Limitations and Future Research

Despite its quite good empirical and theoretical contributions, this study has some limitations that provide valuable directions for further research. First, the research is based on cross-sectional data, which limits the ability to draw long-term cause-and-effect relationships between digital enablers, engagement, and developmental outcomes. Future research can use a longitudinal or panel design to capture dynamic changes over time and behavioral shifts in digital adoption. Second, the study is context-specific and may be biased towards a situation unique to the socioeconomic and policy context of developing or transitioning economies; cross-country or regional studies offer greater generalizability. Third, the digital engagement within this model was assumed in the form of a unidimensional construct, but future studies may consider the greater dimension of the construct in the form of cognitive, emotional, and transactional engagement to discern more

subtle behavioral processes. Fourth, the mediating effect of digital engagement was tested alone, and moderators, including digital literacy, cultural readiness, perceptions of cybersecurity, and social influence, could also be added to the framework. Lastly, future research can integrate new ideas such as AI adoption readiness, digital trust systems, and sustainability-based digital innovation to make the model consistent with emerging digital transformation paradigms.

CONCLUSION

To sum up, this study offers a strong argument to support the idea that the digital infrastructure investment, the efficiency of its governance, and digital access affordability are the factors that play a key role in increasing the utilization of digital services and contributing to socioeconomic development, and digital engagement emerges as a critical behavioral mediator that helps these facilitating factors to be translated into tangible results. The findings substantiate the assumption that the process of digital transformation is not technological or policy-based, but human-based, and that operators, trust, and motivation must be actively involved. The analysis presents a future-sensitive, holistic model of digital development by integrating technological, institutional, and economic enabling factors within a mediated system. It both adds to the theoretical background on the mediating role of engagement and offers practical evidence that policymakers can rely on to create inclusive, user-friendly, and effective digital strategies. Generally, the research supports the idea that sustainable digital development cannot be achieved through access alone, but rather through meaningful engagement that enables people to translate digital opportunities into tangible socioeconomic development.

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