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DIGITAL GOVERNMENT AND QUALITY OF LIFE: UNPACKING THE HUMAN-CENTRED MECHANISMS OF E-GOVERNMENT DEVELOPMENT

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Abstract: *Digital systems are increasingly embedded in everyday life, shaping access to services, institutional interactions, and ultimately human well-being. This study aims to examine how digital government development influences quality of life and to identify the human-centred mechanisms (online services, digital infrastructure, and human capital) through which these effects occur. The analysis is based on a cross-country panel dataset of 76 countries over 2012–2024 (446 observations), using two-way fixed effects models with Driscoll–Kraay standard errors, mechanism decomposition, and a Mundlak approach. The results show that e-government development has a strong positive effect on quality of life in the contemporaneous specification ($\beta = 106.45$; $p < 0.001$), while the lagged effect is weaker ($\beta = 25.96$; $p = 0.075$), indicating predominantly immediate impacts. A 0.1 increase in EGDI is associated with an increase of approximately 10.6 points in the Quality of Life Index. Mechanism analysis reveals that online services ($\beta \approx 31–38$; $p < 0.001$) and digital infrastructure ($\beta \approx 60–67$; $p < 0.01$) are the primary drivers, whereas human capital is not statistically significant. The Mundlak decomposition confirms that both within-country improvements ($\beta = 122.68$; $p < 0.05$) and between-country differences ($\beta = 62.74$; $p < 0.001$) significantly contribute to quality of life.*

Keywords: *human-centred digitalisation, digital government, quality of life, e-government development, online public services, digital infrastructure.*

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INTRODUCTION

The rapid digital transformation of public administration has become a defining feature of contemporary socio-economic development, fundamentally reshaping interactions between governments and citizens. International organisations increasingly recognise digital government not only as a tool for administrative efficiency but also as a driver of human well-being and inclusive development. Digital technologies can improve access to public services, enhance transparency, and strengthen governance capacity, particularly when embedded in broader institutional frameworks (World Bank, 2021; Una et al., 2020). As a result, understanding how digital government translates into improvements in quality of life has become a central research and policy challenge.

At the same time, quality of life is now understood as a multidimensional concept encompassing health, safety, environmental conditions, and access to services. Policy frameworks such as the European Commission's "Digital Decade" emphasise that digital public services should deliver tangible improvements in citizens' daily lives (European Commission, 2021; 2023). However, persistent disparities in digital infrastructure, service accessibility, and digital skills raise concerns about uneven benefits from digitalisation. These challenges have become more visible amid recent global shocks, including the COVID-19 pandemic and the war in Ukraine, in which countries with more advanced digital systems demonstrated greater resilience in maintaining governance continuity and service provision (World Bank, 2022). This highlights the dual role of digital government as both a long-term development driver and a mechanism of crisis resilience.

Nevertheless, empirical evidence on the relationship between digital government and quality of life remains limited and fragmented along at least three dimensions. First, most studies treat e-government as an undifferentiated construct without examining how its constituent dimensions — human capital, digital infrastructure, and online service provision — may operate through different channels and over different time horizons. Second, existing research focuses almost exclusively on aggregate cross-country comparisons at single points in time, leaving within-country dynamics over time largely unexplored. Third, causal identification remains weak, as few studies formally account for the likely reverse causality between national prosperity and e-government development, limiting the policy relevance of reported associations.

This study addresses these gaps and makes several contributions. First, from a theoretical perspective, it advances a human-centred framework of digital government by explicitly conceptualising quality of life as the outcome of distinct transmission channels, online services, digital infrastructure, and human capital, rather than treating digitalisation as a homogeneous process (Palffy et al., 2023). Second, from a methodological perspective, it combines a multi-stage econometric strategy, including two-way fixed effects models with Driscoll–Kraay standard errors, mechanism decomposition, and a Mundlak (correlated random effects) approach, allowing a clear separation of contemporaneous, lagged, within-country, and between-country effects. Third, from an empirical perspective, it provides robust cross-country evidence based on a panel of 76 countries over 2012–2024 (446 observations), demonstrating that digital government has a strong and predominantly immediate effect on quality of life, while also identifying online services and digital infrastructure as the primary drivers and human capital as a non-significant channel.

In this study, human-centred digitalisation is defined as the extent to which digital government systems are designed, implemented, and experienced in ways that directly improve citizens' access to services, reduce administrative burdens, and enhance everyday well-being. Unlike technology-centred approaches, which prioritise efficiency and system performance, a human-centred perspective emphasises usability, accessibility, inclusiveness, and the tangible impact of digital services on individuals' lived experiences. Accordingly, digital government is considered human-centred when it translates technological capabilities into real improvements in service delivery, connectivity, and user interaction with public institutions.

By integrating mechanism-level analysis with within–between decomposition, the study offers a more nuanced understanding of how digital government contributes to human well-being. It shows that digital transformation enhances quality of life primarily through tangible and operational channels, while its effectiveness depends on broader economic and institutional conditions. These insights contribute to both the academic literature and policy debates by clarifying the pathways, magnitude, and timing of digital government effects on societal welfare.

LITERATURE REVIEW

The relationship between digital government and quality of life is increasingly conceptualised as a multidimensional and human-centred process, yet the literature remains fragmented across several partially disconnected strands. A first key debate concerns whether digitalisation should be understood primarily as a technical efficiency tool or as a broader structural transformation of governance systems. A growing body of research supports the latter view, arguing that digital transformation reshapes institutional capacity, transparency, and resilience, thereby influencing both subjective and objective well-being outcomes (Kuanaliyev et al., 2024; Yarovenko et al., 2025; Jarzębowski et al., 2024; Pakhnenko et al., 2025). At the macro level, digital convergence, supported by cybersecurity, transparency, and anti-money laundering effectiveness, enhances governance quality and trust, which are foundational for improved living standards (Kuzior et al., 2022; Vasylieva et al., 2023; Zámek & Zakharkina, 2024). At the same time, digitalisation contributes indirectly to well-being through economic performance, competitiveness, and improvements in the labour market (Jarzębowski et al., 2024; Yarovenko et al., 2025; Alouani et al., 2025; Kuzior & Sira, 2025; Szcześniak & Gorzelańczyk, 2024). However, while this strand establishes a general positive association, it largely treats digital government as a homogeneous construct, leaving open the question of which specific mechanisms drive these effects.

A second strand of the literature focuses on governance quality and institutional design as key transmission channels. Digital government is shown to enhance adaptability and antifragility in the public sector, improving responsiveness to shocks and societal needs (Bartuseviciene & Butkus, 2024). At the same time, the effectiveness of digital transformation depends on managerial competencies and institutional reforms, including the development of human capital in public administration (Androniceanu & Streimikiene, 2025; Stănescu, 2024). Empirical evidence also links digitalisation with reduced corruption, improved accountability, and higher institutional trust, all of which directly affect perceived quality of life (Guemmou, 2024; Palffy & Ablonczy-Mihalyka, 2024; Ntuli et al., 2025; Ugulava, 2026). Conversely,

weak governance, rent-seeking, and institutional erosion may offset these benefits (Ugulava, 2026; Crowley & Mujtaba, 2026), while broader socio-economic and political conditions shape the trajectory of e-government development (Samarkhanov et al., 2025). This strand highlights that digitalisation operates within a wider institutional ecosystem, but does not clearly distinguish between structural conditions and dynamic policy-driven changes.

A third debate shifts attention to human-centred and behavioural mechanisms, emphasising that the impact of digital government depends on user interaction, trust, and adoption. A key unresolved issue in the literature concerns how to conceptualise "human-centred" digital government in operational terms. While the concept is commonly associated with inclusivity, usability, and citizen-oriented service design, it is rarely explicitly linked to measurable components of digital systems. In this study, human-centred digitalisation is understood as those dimensions of e-government that directly shape citizens' interaction with public services and their ability to access, use, and benefit from them. Behavioural economics approaches, including nudging and incentive design, influence engagement with digital services (Crăciun et al., 2025; Burrell et al., 2025), while perceived usefulness, trust, and social influence shape technology acceptance and ultimately well-being outcomes (Budiyanto et al., 2025; Kowalska & Nguyen, 2025; Soussou & Hamrouni, 2025). Complementary factors such as financial literacy and advisory systems further enhance the benefits of digital services (Gupta et al., 2025; Batizani, 2024). These studies suggest that digital government effectiveness depends not only on infrastructure but also on behavioural and cognitive dimensions. However, this literature remains largely micro-oriented and does not systematically connect these mechanisms to macro-level quality-of-life outcomes.

A fourth strand addresses digital inclusion and inequality, highlighting that the benefits of digital government are unevenly distributed. Persistent digital divides across regions, socio-economic groups, and generations limit access to services and reinforce disparities in well-being (Kovac et al., 2024; Valaskova et al., 2025a; 2025b). Addressing these inequalities requires policies promoting digital literacy, equitable access, and inclusive system design (Ruthvika & Hedau, 2025; Kiseľáková et al., 2024). Evidence from developing and informal contexts indicates that infrastructural constraints and weak institutional support are major barriers (Mtengwane, 2024; Huseynov et al., 2025). While this literature underscores distributional issues, it does not fully explain how different components of digital government contribute to or mitigate these inequalities.

A fifth strand provides sector-specific evidence, illustrating how digital government improves quality of life through concrete service channels. In healthcare, digitalisation enhances access and outcomes, including life expectancy (Tossekbayev et al., 2025), while in finance it improves transparency and resource allocation (Darmawati et al., 2025; Filipova et al., 2025). Digital technologies also support sustainability transitions in supply chains and tourism (Gariba et al., 2024; Khatami et al., 2024; Razavi & Sierpinski, 2024) and strengthen resilience during crises such as the COVID-19 pandemic (Mardosaite et al., 2024; Paraschiv et al., 2024). Broader conceptual work links digital governance to evolving welfare frameworks and long-term societal resilience (Oe & Yamaoka, 2025). However, these studies are often sectorally fragmented and lack an integrated, cross-country perspective.

At the same time, a growing body of research highlights the risks and unintended consequences of digitalisation. These include psychosocial pressures in digitalised labour environments (Iordache et al., 2025; Mujtaba, 2025), algorithmic bias and fairness concerns in

AI systems (Wojciechowski & Korjonen-Kuusipuro, 2025; Yarovenko et al., 2024; Pisică & Zaharia, 2025), and broader ethical challenges related to governance and human rights (Crowley & Mujtaba, 2026; Hakobyan et al., 2025; Al-Ashoor et al., 2025). These findings emphasise that digital transformation may produce uneven or even negative outcomes if not accompanied by appropriate regulatory and institutional safeguards.

Finally, the literature recognises the importance of broader socio-economic dynamics in shaping the digital government–quality of life nexus. Digital transformation interacts with labour markets, social structures, and demographic factors (Hong et al., 2024; Chen et al., 2024), while alignment with Sustainable Development Goals and sectoral policies enhances its welfare impact (Makarenko et al., 2025). Institutional transformations and regime changes further influence well-being trajectories (Prati, 2024; Zahorodnia et al., 2026), and local-level governance innovations, including personalised digital services, strengthen citizen-centric outcomes (Sułkowski et al., 2025; Pálffy, 2024).

The existing literature demonstrates that digital government affects quality of life through a complex interplay of institutional, behavioural, infrastructural, and socio-economic mechanisms. However, three key gaps remain. First, existing studies rarely integrate these strands into a unified framework, leading to fragmented explanations. Second, digital government is often treated as an aggregate concept, with limited attention to the distinct roles of its components, such as infrastructure, service delivery, and human capital. Third, there is insufficient distinction between within-country dynamics and cross-country structural differences, limiting understanding of whether improvements in digitalisation translate into welfare gains over time. Addressing these gaps requires a comprehensive empirical approach that combines mechanism decomposition with dynamic panel analysis, providing a more coherent and policy-relevant understanding of how digital government contributes to quality of life.

This study aims to examine how digital government development shapes quality of life, identifying the human-centred mechanisms – online public services, digital infrastructure, and human capital – through which e-government influences societal well-being across countries.

METHODS

This study investigates the impact of digital government development on quality of life using a cross-country panel dataset constructed from internationally comparable sources. The empirical analysis is based on secondary data obtained from three main databases. The dependent variable, the Quality of Life Index (QLI), is sourced from Numbeo (n.d.), which provides a composite measure of living conditions incorporating purchasing power, safety, healthcare, cost of living, and environmental factors. The key explanatory variable, the E-Government Development Index (EGDI) and its subcomponents, human capital (HCI), online services (OSI), and telecommunication infrastructure (TTI), are obtained from the World Bank (n.d.-a). Control variables, including GDP per capita (PPP, constant 2021 international dollars), unemployment rate, political stability, and rule of law, are retrieved from the World Bank (n.d.-b).

The final dataset comprises an unbalanced panel of 76 countries spanning 2012–2024, yielding 446 observations. Due to the non-annual availability of EGDI (typically reported at two-year intervals), the dataset exhibits irregular time spacing, which is explicitly accounted for in the model

specification. Prior to estimation, variables were pre-processed to improve statistical properties and ensure comparability. GDP per capita was transformed using the natural logarithm to address right-skewness and enable elasticity-based interpretation. The unemployment rate was winsorised at the 1st and 99th percentiles to reduce the influence of extreme values. All EGDI-related variables and governance indicators were retained at the level due to their bounded nature.

The empirical strategy proceeds in several stages. First, descriptive statistics and correlation analysis are used to examine the distributional properties of the variables and to identify preliminary relationships. Particular attention is given to skewness, dispersion, and potential multicollinearity, especially given the composite nature of EGDI. Second, the baseline relationship between digital government and quality of life is estimated using a two-way fixed effects (TWFE) model, which controls for unobserved country-specific heterogeneity and common time shocks. The general specification is as follows:

$$QLI_{it} = \beta_1 EGDI_{it} + \beta_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where QLI_{it} denotes the quality of life in the country i at time t, $EGDI_{it}$represents e-government development, X_{it} is a vector of control variables, μ_i captures country fixed effects, and λ_t denotes time fixed effects.

To ensure robust inference in the presence of heteroskedasticity, serial correlation, and cross-sectional dependence, common in macro-panel data, the study employs Driscoll–Kraay standard errors, which provide consistent estimates even when error terms are spatially and temporally correlated. This is particularly relevant given the global nature of digital transformation and shared shocks such as economic crises or technological diffusion.

To identify the channels through which digital government affects quality of life, the aggregate EGDI is decomposed into its three subindices (HCI, OSI, TTI), and alternative model specifications are estimated. These models allow the analysis to distinguish between the roles of human capital, digital infrastructure, and service delivery in shaping welfare outcomes. Given the high correlations between EGDI and its components, the models are estimated separately to avoid multicollinearity bias. The classification of these components as human-centred mechanisms is theoretically justified. OSI represent the direct interface between citizens and government, capturing service accessibility, usability, and availability, and therefore constitutes the most immediate human-centred dimension. TTI reflects the enabling conditions of access, determining whether individuals can effectively use digital services, and thus represents a structural but still human-centred factor. In contrast, HCI reflects broader capabilities to engage with digital systems, but its effect is indirect and mediated through access and service provision. This distinction allows the analysis to differentiate between direct (service and access) and indirect (capacity-based) human-centred mechanisms.

Finally, to disentangle within-country (dynamic) effects from between-country (structural) differences, the study applies a Mundlak (correlated random effects) approach. For each key explanatory variable, country-specific means and deviations from these means are included simultaneously in the model:

$$QLI_{it} = \beta_1 (EGDI_{it} - \bar{EGDI}_i) + \beta_2 \bar{EGDI}_i + \beta_3 X_{it} + \lambda_t + \varepsilon_{it} \quad (2)$$

This specification allows the identification of whether improvements in digital government within countries over time drive changes in quality of life, or whether the relationship is primarily due to persistent cross-country differences. The same decomposition is applied to EGDI subindices to assess mechanism-specific effects.

The adopted methodology combines panel econometric techniques, robust inference procedures, and decomposition strategies to provide a comprehensive and reliable assessment of the relationship between digital government and quality of life, ensuring both statistical rigour and policy relevance.

All empirical analyses and statistical computations were performed using the R programming environment.

RESULTS

The descriptive statistics (Table A1, Appendix A) indicate a balanced panel of 446 observations for 2012–2024, revealing substantial cross-country heterogeneity. E-government development is relatively high (EGDI mean = 0.75; sd = 0.14), placing most countries in the medium-to-high range of digital governance. Among subindices, HCI shows the highest mean (0.82) and lowest variability (sd = 0.12), indicating relatively homogeneous human capital conditions. In contrast, TTI has the lowest mean (0.69) and highest dispersion (sd = 0.21), reflecting pronounced infrastructure disparities that may constrain welfare gains.

The QLI varies considerably (mean = 127.64; sd = 48.17), with negative skewness (−0.81) indicating concentration at higher levels. A similar pattern holds for EGDI and its subindices, especially HCI (skew = −1.34), suggesting clustering near upper bounds and potential saturation effects.

Macroeconomic variables exhibit stronger asymmetry: GDP per capita is highly dispersed and right-skewed, while unemployment shows extreme skewness and kurtosis, indicating outliers and crisis-related shocks. Governance indicators are more balanced. Digital government is less dispersed than economic conditions, yet inequalities persist. This supports the use of within-country panel estimators, as cross-country differences may otherwise bias the relationship between e-government development and quality of life.

The correlation analysis (Table A2) reveals several key patterns. First, there is a strong positive association between EGDI and QLI ($r = 0.72$, $p < 0.001$), indicating that higher digital government development is linked to better living conditions. This holds across subindices, with the strongest correlation for TTI ($r = 0.67$), followed by OSI ($r = 0.60$) and HCI ($r = 0.54$), suggesting infrastructure and service delivery play a central role.

Second, EGDI is highly correlated with its components ($r = 0.80$–0.91), especially with TTI ($r = 0.91$), suggesting a near-linear relationship. This implies that EGDI and its subindices should not be used together in one model due to multicollinearity; separate specifications are required.

Third, GDP per capita correlates strongly with EGDI ($r = 0.73$) and QLI ($r = 0.66$), while political stability shows similar links ($r = 0.67$ with both). This confirms that digitalisation is embedded in broader economic and institutional contexts, requiring appropriate controls.

Finally, unemployment shows weaker negative correlations with EGDI ($r \approx -0.23$) and QLI ($r \approx -0.16$), indicating a secondary role. The results support a positive relationship between EGDI and QLI and justify the use of fixed-effects models with separate specifications.

The TWFE results with Driscoll–Kraay standard errors (Table B1, Appendix B) provide nuanced evidence on the link between e-government and quality of life after controlling for country and time effects. The lagged EGDI shows a positive but weakly significant effect ($\beta = 25.96$; $p = 0.075$), implying that a 0.1 increase in EGDI raises QLI by about 2.6 points. Its significance is evident only under Driscoll–Kraay corrections, highlighting sensitivity to cross-sectional dependence.

Economic development remains the dominant driver: logged GDP per capita is strongly positive and highly significant ($\beta = 37.32$; $p < 0.001$), confirming the central role of income in shaping living standards. Political stability also has a significant positive effect ($\beta = 1.24$; $p < 0.001$), while the rule of law is not significant, possibly due to limited within-country variation.

Unemployment does not significantly affect quality of life, suggesting that short-term labour-market fluctuations are less important than structural factors or are mitigated by policy responses. Digital government has a positive but moderate and context-dependent effect, whereas economic development and political stability are the primary determinants of well-being. EGDI thus acts as a complementary rather than a substitutive factor.

The specification without a lag (Table B2, Appendix B) provides clearer evidence on digital government. EGDI is large, positive, and highly significant ($\beta = 106.45$; $p < 0.001$), implying that a 0.1 increase raises QLI by about 10.6 points. Compared to the lagged model, the effect is stronger, suggesting that digitalisation impacts quality of life more contemporaneously.

Control variables confirm the key role of structural factors. Logged GDP per capita remains positive and significant ($\beta = 19.31$; $p < 0.001$), while political stability shows a strong effect ($\beta = 1.15$; $p < 0.001$). Unemployment remains insignificant.

The rule of law is negative and marginally insignificant ($p \approx 0.10$), likely due to multicollinearity or limited variation. The results highlight that digital government development, economic prosperity, and political stability jointly shape quality of life, with EGDI emerging as a strong and policy-relevant determinant when temporal alignment is correctly specified.

The mechanism decomposition (Table B3, Appendix B) identifies which dimensions of digital government drive quality of life and highlights differences between joint and separate models.

In the full model, OSI and TTI are the main drivers, while HCI is not significant. OSI is positive and highly significant ($\beta = 31.45$; $p < 0.001$), indicating that improved digital services directly enhance living standards. TTI is also strong ($\beta = 60.86$; $p < 0.01$), with a 0.1 increase raising QLI by about 6.1 points. In contrast, HCI is insignificant, likely reflecting saturation and limited variation.

Separate models confirm these results: OSI ($\beta = 38.26$; $p < 0.001$) and TTI ($\beta = 67.25$; $p < 0.01$) remain robust, with larger coefficients due to reduced multicollinearity. HCI remains insignificant ($\beta = -24.30$; $p = 0.467$), indicating it does not independently drive within-country QLI changes.

Controls are consistent: GDP per capita is strongly positive, and political stability remains the key institutional factor ($\beta \approx 1.10$–1.40; $p < 0.001$). Unemployment is mostly insignificant,

and the rule of law has little effect. Digital government improves quality of life mainly through infrastructure and service delivery, suggesting that investments in these areas yield the most immediate welfare gains.

The Mundlak specification (Table C1, Appendix C) shows that the link between e-government and quality of life operates through both within- and between-country effects. The within-country EGDI component is positive and significant ($\beta = 122.68$; $p < 0.05$), indicating that a 0.1 increase in EGDI raises QLI by about 12.3 points, suggesting strong effects of digital reforms.

The between-country component is also positive and highly significant ($\beta = 62.74$; $p < 0.001$), showing that countries with higher average EGDI have a higher quality of life. The larger within effect suggests that changes over time have stronger marginal impacts than structural differences.

Control variables confirm key patterns: GDP per capita is strongly positive ($\beta = 14.99$; $p < 0.001$), political stability remains significant ($\beta = 1.14$; $p < 0.001$), and the rule of law becomes positive and significant ($\beta = 0.32$; $p < 0.01$). Unemployment remains insignificant.

High explanatory power (Adj. $R^2 = 0.736$; Within $R^2 = 0.683$) confirms model validity. Overall, EGDI emerges as a significant, policy-relevant driver of quality of life through both structural advantages and dynamic improvements.

The Mundlak decomposition for subindices (Table C2, Appendix C) clarifies how digital government affects quality of life by separating within- and between-country effects. In the full model, OSI emerges as the most robust driver: both within ($\beta = 37.75$; $p < 0.05$) and between ($\beta = 41.09$; $p < 0.05$) effects are positive and significant, confirming that digital service delivery is a key transmission channel.

For TTI, the effect is mainly structural: the between-component effect is significant ($\beta = 40.74$; $p < 0.05$), whereas the within-component effect is insignificant, suggesting slower or indirect effects. HCI is insignificant in both dimensions, likely due to saturation and low variability.

Separate models confirm these results. OSI remains strong (within $\beta = 49.07$; $p < 0.05$; between $\beta = 45.91$; $p < 0.01$), reinforcing its central role. TTI shows a significant between-effect ($\beta = 43.77$; $p < 0.01$) and only weak within-effect significance ($p < 0.10$), indicating gradual effects. HCI remains insignificant, suggesting it is a background condition rather than a direct driver.

Across all specifications, control variables remain stable and highly significant. GDP per capita consistently exhibits a strong positive effect, confirming the central role of economic development. Political stability and rule of law are also positive and significant, highlighting the importance of institutional quality in translating digital and economic progress into welfare gains. Interestingly, unemployment becomes significant in some specifications (particularly in the full and OSI models), suggesting that labour market conditions may have a more nuanced role once within–between variation is properly accounted for.

The Mundlak decomposition demonstrates that the impact of digital government on quality of life is channel-specific and operates through both structural and dynamic mechanisms, with online services emerging as the most powerful and immediate driver, infrastructure as a long-term enabler, and human capital playing a limited independent role within the observed time horizon.

DISCUSSION

The empirical results point to two central findings. First, e-government development is strongly and positively associated with quality of life across all specifications. Second, the temporal structure of this association is informative: the contemporaneous coefficient is substantially larger than the lagged coefficient, suggesting that the relationship operates primarily through immediate channels - such as reduced transaction costs in public service delivery and improved accessibility of government information - rather than through gradual structural accumulation. However, the magnitude of the contemporaneous estimate should be interpreted as an upper bound, as the current identification strategy cannot fully account for simultaneity bias arising from the joint determination of e-government investment and welfare outcomes.This aligns with the literature that emphasises the direct roles of service accessibility and administrative efficiency in shaping well-being (Kuanaliyev et al., 2024; Jarzębowski et al., 2024; Valaskova et al., 2025b). At the same time, the weaker and only marginally significant lagged effect confirms that these benefits are primarily immediate rather than delayed, supporting the view that digital government operates through real-time interaction channels rather than long-term accumulation processes (Bartuseviciene & Butkus, 2024; Stănescu, 2024).

From a theoretical perspective, the study contributes by refining the human-centred understanding of digital government through a mechanism-based approach. The decomposition results show that the impact of digitalisation is highly channel-specific: online services and digital infrastructure emerge as the primary drivers of quality-of-life improvements, consistent with studies linking connectivity and service delivery to welfare outcomes (Gariba et al., 2024; Tossekbayev et al., 2025; Paraschiv et al., 2024). In contrast, the absence of a statistically significant effect of human capital challenges parts of the literature that emphasise skills and education as central drivers (Androniceanu & Streimikiene, 2025; Kiseľáková et al., 2024). This finding advances theory by suggesting that human capital primarily operates as an enabling background condition, while tangible, user-oriented components of digitalisation generate more immediate welfare effects.

From a methodological perspective, the study contributes by integrating multiple econometric approaches to disentangle different dimensions of the digital government–quality of life nexus. The combination of TWFE models with Driscoll–Kraay standard errors, mechanism decomposition, and the Mundlak specification allows identification of contemporaneous versus lagged effects and of within-country versus between-country dynamics. The Mundlak results show that both within-country improvements and structural cross-country differences in e-government development significantly affect quality of life, with stronger marginal effects from within-country changes. This provides new evidence that dynamic policy reforms and incremental improvements are as important as structural digital capacity, aligning with research on digital convergence and transformation pathways (Yarovenko et al., 2025; Pakhnenko et al., 2025).

At the same time, the findings reinforce the importance of broader socio-economic and institutional contexts. The strong and consistent effects of GDP per capita and political stability confirm that digitalisation operates within a wider development ecosystem, supporting prior evidence that governance quality and economic prosperity are essential for translating digital progress into improved living standards (Makarenko et al., 2025; Samarkhanov et al., 2025; Kuzior et al., 2022). This highlights an important empirical and policy implication: digital

government should be understood as a complementary factor that enhances, rather than substitutes for, fundamental economic and institutional conditions.

The results also provide important insights into inclusivity and limitations, extending the empirical contribution to distributional considerations. While the positive effects of digitalisation are robust, unequal access and persistent digital divides may constrain their benefits (Kovac et al., 2024; Valaskova et al., 2025a; Ruthvika & Hedau, 2025). The stronger role of infrastructure relative to human capital suggests that access remains a binding constraint, particularly in less developed contexts (Huseynov et al., 2025; Mtengwane, 2024). Moreover, risks related to ethical governance, data bias, and psychosocial impacts highlight that digital transformation may produce unintended consequences in the absence of appropriate regulatory frameworks (Wojciechowski & Korjonen-Kuusipuro, 2025; Iordache et al., 2025). These findings extend the literature by emphasising that the effectiveness of digital government depends on inclusive design and institutional safeguards.

Several limitations of this analysis warrant explicit discussion. First, the dependent variable - Numbeo's Quality of Life Index - is derived from self-selected respondents on a crowd-sourced online platform. Countries with greater internet penetration are likely to generate more responses, which may introduce a compositional bias: to the extent that EGDI correlates with internet access, part of the observed association may reflect sample composition rather than genuine welfare effects. While country fixed effects absorb time-invariant differences in Numbeo participation across countries, they cannot account for time-varying changes in the respondent pool within countries. Replication of these results using institutionally sourced welfare measures, such as the UNDP Human Development Index or the Legatum Prosperity Index, would provide a valuable robustness check. Second, the empirical strategy does not fully resolve endogeneity concerns. Reverse causality - whereby higher quality of life generates greater fiscal capacity and institutional demand for e-government investment - may produce an upward bias in the estimated coefficients. The lagged EGDI specification partially mitigates contemporaneous simultaneity, but cannot eliminate it entirely. A more rigorous identification strategy would employ instrumental variables or a difference-in-differences design exploiting exogenous policy variation. Third, the biennial structure of EGDI data limits the effective time dimension to 2–7 observations per country. This raises concerns about the finite-sample reliability of the Driscoll–Kraay standard error correction, which relies on large-T asymptotics. Country-clustered standard errors should be considered as a complementary robustness check. Fourth, the country-level analysis masks within-country heterogeneity in both digital access and quality of life. Future research should seek subnational data to examine regional disparities, test for nonlinear relationships between e-government development and welfare outcomes (e.g., diminishing returns at higher EGDI levels via threshold or quantile regression models), and assess the distributional impacts of digital access across population subgroups.

CONCLUSIONS

This study set out to analyse how digital government development influences quality of life, with a particular emphasis on identifying the human-centred mechanisms through which e-government contributes to societal well-being across countries.

The empirical analysis was based on an unbalanced panel dataset of 76 countries over the period 2012–2024 (446 observations), combining data on quality of life, e-government development, and macroeconomic and institutional indicators. The study employed a multi-stage econometric strategy, including descriptive and correlation analyses, two-way fixed-effects models with Driscoll–Kraay standard errors, mechanism decomposition using EGDI subindices, and a Mundlak (correlated random effects) approach to distinguish within-country dynamics from cross-country structural differences. This framework ensured robust inference and allowed for a comprehensive examination of both direct and channel-specific effects of digital government.

The results provide several key findings. First, the baseline two-way fixed effects model shows that e-government development has a positive and statistically significant effect on quality of life in the contemporaneous specification ($\beta = 106.45$; $p < 0.001$), with a 0.1 increase in EGDI associated with approximately a 10.6-point increase in QLI. Second, the lagged specification reveals a weaker and only marginally significant effect ($\beta = 25.96$; $p = 0.075$), suggesting that the impact of digital government is more immediate than delayed. Third, the mechanism analysis demonstrates that online services ($\beta \approx 31–38$; $p < 0.001$) and telecommunication infrastructure ($\beta \approx 60–67$; $p < 0.01$) are the main drivers of quality-of-life improvements, while human capital does not exhibit a statistically significant effect. Fourth, the Mundlak decomposition confirms that both within-country improvements ($\beta = 122.68$; $p < 0.05$) and between-country differences ($\beta = 62.74$; $p < 0.001$) in e-government development contribute to higher quality of life, with a stronger marginal impact from within-country changes. Fifth, across all models, economic development ($\beta \approx 15–37$; $p < 0.001$) and political stability ($\beta \approx 1.1–1.4$; $p < 0.001$) emerge as robust and dominant determinants, highlighting the importance of the broader socio-economic and institutional context.

These findings have important policy implications and further clarify the meaning of human-centred digitalisation in practice. In particular, the results indicate that digital government is human-centred when it improves citizens' direct access to services, reduces interaction costs, and enhances the usability and responsiveness of public administration. First, governments should prioritise the development of user-oriented online public services, as improvements in accessibility, usability, and service delivery generate the most immediate and measurable gains in quality of life. Second, sustained investment in digital infrastructure is essential, as it provides the structural foundation for inclusive access to these services, even if its effects materialise more gradually. Third, policies focused solely on human capital development are unlikely to produce significant welfare gains unless complemented by functional digital systems and service delivery mechanisms. Fourth, digital transformation strategies should be embedded within a broader framework of economic development and institutional stability, as the effectiveness of e-government depends critically on income levels and governance quality. Finally, the significance of both within-country and between-country effects suggests that policymakers should pursue a dual strategy combining long-term capacity

building with continuous incremental reforms, ensuring that digital government evolves dynamically while maintaining structural strength.

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Appendix

Appendix A. Descriptive Statistics and Correlation Analysis

Table A1. Descriptive statistics of variables

Variable	Mean	SD	Min	Max	Skewness	Kurtosis
EGDI	0.75	0.14	0.26	0.98	-0.77	0.10
EGDI_HCI	0.82	0.12	0.32	1.00	-1.34	2.40
EGDI_OSI	0.76	0.17	0.24	1.00	-0.72	-0.17
EGDI_TTI	0.69	0.21	0.11	1.00	-0.63	-0.41
QLI	127.64	48.17	-49.50	208.50	-0.81	0.42
GDP per capita (PPP)	39,375.50	24,658.62	2,470.50	133,571.96	0.94	1.13
Unemployment (%)	7.43	5.42	0.11	33.27	1.99	4.64
Political stability	68.21	14.52	20.10	91.45	-0.59	-0.37
Rule of law	64.19	15.69	35.37	93.26	0.11	-1.23

Table A2. Correlation matrix of variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) EGDI	1.00								
(2) HCI	0.80***	1.00							
(3) OSI	0.83***	0.49***	1.00						
(4) TTI	0.91***	0.64***	0.59***	1.00					
(5) QLI	0.72***	0.54***	0.60***	0.67***	1.00				
(6) ln(GDP per capita)	0.73***	0.71***	0.50***	0.67***	0.66***	1.00			
(7) Unemployment (winsorised)	-0.23***	-0.02	-0.27***	-0.24***	-0.16***	-0.23***	1.00		
(8) Political stability	0.67***	0.70***	0.46***	0.60***	0.67***	0.70***	-0.15***	1.00	
(9) Rule of law	0.45***	0.44***	0.35***	0.38***	0.49***	0.45***	-0.17***	0.52***	1.00

Appendix B. Two-Way Fixed Effects Estimation Results and Mechanism Decomposition

Table B1. Two-way fixed effects estimation results (dependent variable: QLI)

Variable	Coefficient	Driscoll–Kraay SE	t-statistic	p-value
EGDI (t−1)	25.958	14.535	1.786	0.075*
ln(GDP per capita)	37.325	8.740	4.271	0.000***
Unemployment (winsorised)	0.538	0.440	1.221	0.223
Political stability	1.244	0.330	3.767	0.000***
Rule of law	0.030	0.034	0.883	0.378
Constant	–	–	–	–

Note. Two-way fixed effects (country and year) included. Driscoll–Kraay standard errors reported. EGDI is lagged by one period. Significance codes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table B2. Two-way fixed effects estimation results (Driscoll–Kraay standard errors, no lag specification)

Variable	Coefficient	DK SE	t-statistic	p-value
EGDI	106.448	27.368	3.890	0.000***
ln(GDP per capita)	19.313	3.727	5.183	0.000***
Unemployment (winsorised)	0.171	0.379	0.452	0.652
Political stability	1.154	0.133	8.694	0.000***
Rule of law	-0.100	0.061	-1.632	0.104

Model statistics. Observations – 370. Countries – 76. Unbalanced panel (T = 2–6).
Note. Two-way fixed effects (country and year) included. Driscoll–Kraay standard errors reported. Variables expressed in levels except GDP per capita (logarithm). Unemployment is winsorised at the 1st and 99th percentiles. Significance codes: *** p < 0.01, ** p < 0.05, * p < 0.1

Table B3. Mechanism decomposition: Two-way fixed effects results (Driscoll–Kraay standard errors)

Variable	(1) Full model	(2) HCI only	(3) OSI only	(4) TTI only
EGDI_HCI	-36.737 (34.619)	-24.299 (33.388)	–	–
EGDI_OSI	31.452*** (8.178)	–	38.258*** (10.853)	–
EGDI_TTI	60.862** (19.621)	–	–	67.246** (21.336)
ln(GDP per capita)	15.278** (4.760)	37.046*** (3.249)	26.958*** (2.991)	21.602*** (3.557)
Unemployment (winsorised)	0.121 (0.381)	0.589* (0.243)	0.451 (0.306)	0.108 (0.438)
Political stability	1.101*** (0.099)	1.396*** (0.165)	1.274*** (0.165)	1.165*** (0.072)
Rule of law	-0.053 (0.045)	-0.125* (0.064)	-0.101* (0.058)	-0.097 (0.063)

Note. Standard errors in parentheses (Driscoll–Kraay). Two-way fixed effects (country and year) included. Unbalanced panel (N = 370, countries = 76). Significance codes: *** p < 0.01, ** p < 0.05, * p < 0.10

Appendix C. Mundlak Decomposition Results and Within–Between Effects Analysis

Table C1. Mundlak decomposition results (dependent variable: Quality of Life Index)

Variable	Coefficient	DK SE	t-statistic	p-value
EGDI (within)	122.681	42.157	2.910	0.027**
EGDI (between mean)	62.741	9.070	6.917	0.000***
ln(GDP per capita)	14.995	0.519	28.894	0.000***
Unemployment (winsorised)	0.476	0.345	1.381	0.217
Political stability	1.144	0.171	6.689	0.001***
Rule of law	0.315	0.056	5.622	0.001***

Model statistics. Observations – 446. Fixed effects – Year (7 periods). Adjusted $R^2 = 0.736$. Within $R^2 = 0.683$. RMSE = 24.4.
Note. Driscoll–Kraay standard errors (lag = 1). EGDI (within) represents deviations from country-specific means. EGDI (between) represents country-specific averages. Significance codes: *** p < 0.01, ** p < 0.05, * p < 0.10

Table C2. Mundlak decomposition for EGDI subindices (Driscoll–Kraay standard errors)

Variable	(1) Full model	(2) HCI only	(3) OSI only	(4) TTI only
HCI (within)	-58.072 (76.841)	-36.181 (83.170)	–	–
HCI (mean)	-32.222 (30.353)	8.393 (18.874)	–	–
OSI (within)	37.754* (14.573)	–	49.072* (16.028)	–
OSI (mean)	41.093* (14.205)	–	45.906** (10.696)	–
TTI (within)	69.634 (45.084)	–	–	82.219* (42.285)
TTI (mean)	40.737* (15.007)	–	–	43.765** (10.657)
ln(GDP per capita)	15.396*** (0.468)	20.369*** (2.848)	18.125*** (0.618)	14.862*** (1.002)
Unemployment (winsorised)	0.723* (0.230)	0.505 (0.288)	0.668* (0.282)	0.459 (0.405)
Political stability	1.156*** (0.184)	1.334*** (0.247)	1.240*** (0.170)	1.157*** (0.132)
Rule of law	0.328** (0.069)	0.344** (0.074)	0.306** (0.058)	0.338*** (0.044)

Model statistics. Observations – 446. Fixed effects – Year (7 periods). Adjusted R^2 = 0.72–0.74. Within R^2 = 0.66–0.69.

Note. Driscoll–Kraay standard errors (lag = 1). Standard errors in parentheses. "Within" denotes deviations from country means; "mean" denotes country averages. Significance codes: *** p < 0.01, ** p < 0.05, * p < 0.10