

PUBLIC-SECTOR DIGITALISATION AND ECONOMIC GROWTH IN THE EU: THE ROLE OF E-GOVERNMENT USE AND DIGITAL GOVERNMENT CAPACITY

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ABSTRACT

This study investigates whether public-sector digitalisation is associated with real GDP per capita growth in the EU-27 and whether this relationship depends on time dynamics and governance quality. The analysis combines two measures of digital government development: a behavioural indicator capturing the share of individuals interacting online with public authorities (Eurostat), with adjustments for the 2021-2022 series break, and the Public-Sector Digital Capacity Index (PSDCI), developed from the eGovernment Benchmark dimensions for a shorter panel. The empirical strategy applies two-way fixed-effects models with country and year effects, including lagged specifications, an interaction between digitalisation and Government Effectiveness (WGI), and robustness checks using Driscoll-Kraay standard errors and placebo lead tests. The findings show no statistically significant average contemporaneous relationship between e-government use and economic growth. PSDCI estimates are positive but remain statistically uncertain due to the limited time dimension. However, when lagged effects and institutional conditions are considered, a relationship between digitalisation and growth becomes evident, particularly at lower levels of governance effectiveness. The results suggest that public-sector digitalisation does not automatically translate into higher economic growth. Its contribution depends on the timing of effects, the measurement approach, and the institutional environment in which digital reforms are implemented. These findings highlight the importance of considering governance capacity and dynamic effects when evaluating the economic impact of digital government transformation.

Keywords: public-sector digitalisation, e-government, economic, growth, government effectiveness, digital government capacity

1. INTRODUCTION

Public-sector digitalisation has become a central component of the EU's broader development agenda. Within the Digital Decade framework, the digital transformation of public services is identified as one of the Union's four key pillars, together with digital skills, digital infrastructure, and business digitalisation (European Commission, 2023, 2024).

International organisations such as the OECD similarly emphasise that digital government extends beyond the implementation of technological solutions. It represents a broader governance approach based on effective data use, platform-based service delivery, user-centred

design, and institutional coordination (OECD, 2024). However, a gap remains between policy expectations and empirical evidence. If digitalisation functions as a driver of productivity and economic performance, its effects should be reflected in measurable growth outcomes, although identifying such effects requires careful control for persistent cross-country differences and common macroeconomic shocks. Theoretically, more efficient digital public services may reduce administrative burdens, lower transaction costs, and improve resource allocation, potentially contributing to higher productivity and GDP per capita growth. Nevertheless, digital government differs from traditional technology adoption because it is strongly embedded in organisational structures and institutional frameworks (Marjohan et al., 2026). Furthermore, many benefits of digital public services involve broader dimensions of public value, including accessibility, accountability, trust, and service quality, which may not be immediately captured in annual economic growth indicators (Panagiotopoulos et al., 2019). Additional measurement challenges arise from difficulties in assessing public-sector productivity and linking improvements in service delivery directly to national economic outcomes (Dunleavy, 2017).

This study examines whether public-sector digitalisation is associated with real GDP per capita growth in the EU-27 and investigates whether this relationship varies across institutional environments and emerges with a time lag. The contribution of the study lies in analysing public-sector digitalisation as a distinct potential growth mechanism, combining behavioural and capacity-based measures of digital transformation, and demonstrating that the relationship between digitalisation and economic growth depends on institutional quality and the timing of effects.

The remainder of the article is structured as follows. The next section reviews the theoretical and empirical literature on digital government, administrative burden, governance quality, and economic growth. Section 3 presents the data, variables, and econometric methodology. Section 4 discusses the empirical results and robustness analyses. Section 5 concludes by outlining the main findings, limitations, and directions for future research.

2. LITERATURE REVIEW

The relationship between digitalisation and economic growth has become an increasingly important topic in contemporary macroeconomic and public policy research. The theoretical rationale for public-sector digitalisation as a potential driver of economic performance can be understood through three interconnected mechanisms: reductions in transaction costs and administrative burdens, improvements in governance quality and transparency and the role of institutional capacity in determining whether digital reforms generate measurable productivity effects.

The first mechanism relates to efficiency gains arising from the reduction of administrative frictions. Digital public services can simplify interactions between governments, citizens, and businesses by reducing time requirements, compliance costs, and procedural complexity associated with activities such as tax filing, licensing, and access to public services. The administrative burden literature emphasises that such costs extend beyond direct financial expenses and include learning, information, and compliance requirements that may influence business decisions and investment behaviour (Baekgaard & Tankink, 2022; Petersen et al., 2024). Empirical evidence supports this perspective, showing that digital tax systems and e-filing solutions can reduce firms' compliance costs by lowering the time required for administrative procedures and reducing the need for direct interactions with public authorities (Kochanova et al., 2020). Similar evidence from European contexts suggests that digital public-sector solutions can strengthen administrative capacity and improve public resource mobilisation through more efficient service delivery. At the same time, digital transformation may introduce new challenges related to cybersecurity, regulatory adaptation, and data governance (Frățilă et al., 2023; Desyatnyuk & Ptashchenko, 2024).

A second mechanism concerns the institutional effects of digital government. Beyond efficiency improvements, digitalisation may enhance transparency, accountability, and traceability in public administration by reducing information asymmetries and limiting opportunities for discretionary practices (Santiso, 2022). Evidence from EU Member States indicates that higher levels of e-government development are associated with improved transparency outcomes (Cifuentes-Faura, 2022), supporting the argument that digital government may contribute to long-term economic performance through better institutional quality. Similarly, cross-country evidence links digital governance indicators with lower levels of corruption, although the strength of these relationships differs across governance dimensions (Seiam & Salman, 2024; Zou et al., 2023).

The third mechanism highlights the importance of institutional capacity and implementation conditions. Digitalisation should not be interpreted as an independent technological shock that automatically produces economic benefits. Instead, its effectiveness depends on organisational adaptation, regulatory frameworks, interoperability, managerial capacity and the ability of institutions to integrate digital tools into existing administrative processes. Recent empirical research increasingly incorporates interactions between digitalisation and institutional quality, suggesting that the economic effects of digital transformation are conditional on the broader governance environment. For example, European Central Bank research demonstrates that the relationship between digitalisation and economic performance may depend on institutional conditions and may become more visible over longer time horizons rather than in short-term estimates (European Central Bank, 2022). Similarly, studies examining government digitalisation emphasise governance-related mechanisms through which digital reforms influence economic outcomes (Ding et al., 2025). This perspective also explains why immediate macroeconomic effects may be difficult to identify. Economic growth indicators are influenced by numerous short-term fluctuations, while the benefits of public-sector digitalisation often require time to materialise due to organisational adjustment, learning processes, and gradual adoption by users and institutions.

However, empirical research is complicated by significant differences in how public-sector digitalisation is measured. Many studies rely on behavioural indicators, such as the share of citizens using online public services, which capture actual adoption and therefore reflect potential efficiency gains. Nevertheless, these measures also incorporate demand-side factors, including digital skills, trust, education, and accessibility constraints. Evidence from European countries shows that e-government use is shaped not only by service availability but also by institutional trust and socio-economic characteristics (Pérez-Morote et al., 2020). Similarly, research indicates that education levels influence digital service adoption, while technological infrastructure alone does not necessarily guarantee higher usage rates (Horobeț et al., 2023). Therefore, usage-based indicators should be interpreted as measures of realised digital engagement rather than pure measures of public-sector digital capacity.

To capture broader dimensions of digital maturity, the European Union applies the eGovernment Benchmark framework, which evaluates public services according to dimensions such as user centricity, transparency, digital enablers, and cross-border accessibility (European Commission, 2023, 2025). These indicators provide a broader assessment of institutional capacity for digital service provision, although composite measures also involve methodological challenges related to weighting, aggregation, and comparability (Greco et al., 2019). Similar challenges exist when comparing different international frameworks, such as EU benchmarking systems and UN-based digital government indicators, which differ in conceptual scope and measurement approaches (Paroški, 2025).

Beyond technological maturity, recent literature emphasises that effective digital government requires balancing technological development with public values, including inclusion, fair-

ness, accountability, and user-centred design. These dimensions influence both service adoption and public trust (Weigl et al., 2024). Accordingly, digital government outcomes should be understood as the result of interactions between technological capacity, institutional arrangements, and user behaviour. The present study contributes to this measurement debate by combining two complementary perspectives: a long-term behavioural indicator of e-government usage and a shorter-term composite measure of public-sector digital capacity based on eGovernment Benchmark dimensions.

The empirical evidence regarding the growth effects of digital government remains mixed. Although numerous studies identify positive relationships between government digitalisation and economic performance, results vary depending on measurement approaches, institutional contexts, and methodological designs. Majeed (2020), for example, finds that digital government indicators are positively associated with economic performance in developing economies, while Ding et al. (2025) demonstrate that government digitalisation can promote growth through mechanisms such as reduced administrative barriers and improved governance. Other research identifies positive relationships between e-government development and productivity, although with considerable heterogeneity across income groups (Faid et al., 2020).

Within the European context, many studies examine broader digitalisation indicators, such as DESI-based measures, and frequently report positive associations with GDP per capita and economic growth (Mura & Donath, 2023; Magoutas et al., 2024; Török, 2024; Lobonț et al., 2025; Aumeboonsuke & Caplanova, 2026). However, these indicators combine public and private-sector digitalisation, making it difficult to isolate the specific contribution of digital public services. More targeted research on public-sector digitalisation often focuses on intermediate outcomes, such as improved tax administration, procurement efficiency, and productivity effects. For example, regional European evidence suggests that e-government development is positively associated with total factor productivity, particularly when lagged effects are considered (Rehman & Nunziante, 2023).

A growing body of research has therefore shifted attention from average effects toward dynamic and conditional relationships. Studies distinguishing between short-term and long-term effects frequently find stronger evidence of economic benefits over longer periods. European Central Bank research indicates that digital transformation may generate limited immediate effects but stronger long-run impacts as adoption and institutional adaptation progress (European Central Bank, 2022). Similar findings suggest that the positive effects of online public services may emerge gradually through learning and adjustment mechanisms (Ha, 2024).

Recent studies also emphasise that governance quality conditions the economic impact of digital reforms. Digitalisation may contribute to growth by improving access to public services, reducing administrative costs, and strengthening institutional performance, but these effects depend on implementation capacity. Evidence suggests that governance dimensions such as government effectiveness, regulatory quality, and rule of law are particularly relevant, while effects on corruption reduction may be less consistent (Zou et al., 2023). Similarly, digital procurement systems appear to generate stronger benefits in environments with higher institutional capacity (Kochanova et al., 2020).

Based on this theoretical and empirical background, the study tests the following hypotheses:

H₁: Public-sector digitalisation is positively associated with real GDP per capita growth in EU Member States.

H₂: The relationship between public-sector digitalisation and economic growth is more likely to emerge with a time lag rather than contemporaneously.

H₃: The relationship between public-sector digitalisation and economic growth depends on institutional capacity, with government effectiveness moderating this association.

H₄: A quality and maturity-based measure of public-sector digitalisation (PSDCI) demonstrates a stronger association with economic growth than a usage-based digitalisation indicator.

3. DATA AND METHODOLOGY

3.1. DATA SOURCES AND VARIABLES

This study investigates the relationship between public-sector digitalisation and real GDP per capita growth in the EU-27 using an annual country-level panel covering 2015–2024. The empirical design combines macroeconomic outcome data, digital public-service usage data, and digital-environment controls.

The dependent variable is annual growth in real GDP per capita, derived from Eurostat real GDP per capita data. It is measured as annual real GDP per capita growth, computed as the log difference in real GDP per capita:

$$Growth_{-it} = \Delta \ln(GDPpc_{-real_{-it}}) = \ln(GDPpc_{-real_{-it}}) - \ln(GDPpc_{-real_{-i}, t-1}) \quad (1)$$

This transformation is commonly applied in panel growth models, as it approximates percentage changes over time and allows the analysis to focus on within-country variation rather than differences in economic levels across countries.

The main explanatory variable is a usage-based measure of public-sector digitalisation, denoted as PSD_{it} , which captures the share of individuals using the internet to interact with public authorities. Conceptually, this indicator reflects the realised adoption of digital public services and corresponds closely to the transaction-cost reduction and administrative-burden mechanisms discussed in the literature. Previous research suggests that digital government can improve economic efficiency by facilitating interactions with public institutions, lowering compliance costs, and increasing access to public services, although the magnitude of these effects depends on institutional conditions and socio-digital factors (Martins & Veiga, 2022; Kochanova et al., 2020; Petersen et al., 2024).

The baseline specifications include household internet access from Eurostat (isoc_ci_in_h) as a measure of digital infrastructure availability. Extended models additionally incorporate the share of ICT specialists in total employment (isoc_sks_itspt) to capture digital capabilities within the economy. Institutional quality is measured using the Worldwide Governance Indicators (WGI), including Government Effectiveness, Rule of Law, Control of Corruption, and Regulatory Quality. Investment intensity is controlled through gross fixed capital formation as a percentage of GDP, obtained from Eurostat (tec00011). For the shorter post-2020 period, the analysis introduces a composite Public-Sector Digital Capacity Index (PSDCI), constructed from legacy dimensions of the eGovernment Benchmark framework.

Following the integration of all country-year datasets, the resulting panel is partially unbalanced due to limited missing observations among selected explanatory variables. This approach is consistent with standard practices in applied panel-data research, as it retains the maximum available within-country information while avoiding unnecessary loss of observations (Cameron & Miller, 2015; Millo, 2017).

For transparency, Table 1 provides an overview of the variables included in the empirical analysis, including their definitions, database codes, and sources.

Table 1. Variables used in the empirical analysis

Variable name	Code / symbol	Definition	Source
Real GDP per capita growth	Growth_it	Annual growth rate of real GDP per capita, calculated as $\Delta \ln(\text{GDPpc_real_it})$.	Constructed from Eurostat SDG_08_10
Public-sector digitalisation proxy	PSD_it / psd_proxy	Share of individuals using the internet to interact with public authorities.	Eurostat, isoc_r_gov_i
Household internet access	Internet_it / internet_access	Share of households with access to the internet.	Eurostat, isoc_ci_in_h
ICT specialists	ICT_it / ict_spec	Share of employed ICT specialists in total employment.	Eurostat, isoc_sks_itspt
Government effectiveness	GE_it / wgi_ge	Worldwide Governance Indicator estimate for Government Effectiveness.	Worldwide Governance Indicators, GE.EST
Rule of law	RL_it / wgi_rl	Worldwide Governance Indicator estimate for Rule of Law.	Worldwide Governance Indicators, RL.EST
Control of corruption	CC_it / wgi_cc	Worldwide Governance Indicator estimate for Control of Corruption.	Worldwide Governance Indicators, CC.EST
Regulatory quality	RQ_it / wgi_rq	Worldwide Governance Indicator estimate for Regulatory Quality.	Worldwide Governance Indicators, RQ.EST
Investment intensity	Inv_it / gfcf_gdp	Gross fixed capital formation expressed as a percentage of GDP.	Eurostat, tec00011
PSDCI legacy, equal-weighted	PSDCI^EQ_it	Composite Public-Sector Digital Capacity Index based on legacy eGovernment Benchmark dimensions using equal weights.	Constructed from eGovernment Benchmark legacy indicators
PSDCI legacy, PCA-weighted	PSDCI^PCA_it	Composite Public-Sector Digital Capacity Index based on legacy eGovernment Benchmark dimensions with weights derived from principal component analysis (PCA).	Constructed from eGovernment Benchmark legacy indicators

Source: Authors' compilation based on Eurostat, Worldwide Governance Indicators, and European Commission eGovernment Benchmark data

A complete list of intermediate, lagged, component and interaction variables is reported in Appendix Table A1.

The selection of variables follows established approaches in the digital-government literature. Usage-based indicators are particularly appropriate when the objective is to capture the actual adoption of digital public services rather than only the availability or technological sophistication of such services. However, previous research demonstrates that e-government usage is influenced by broader factors, including institutional trust, digital accessibility, and individual capabilities. Therefore, usage-based measures should be interpreted primarily as indicators of realised digital engagement rather than direct measures of public-sector digital capacity (Pérez-Morote et al., 2020; Horobeţ et al., 2023). This consideration motivates the inclusion of digital infrastructure controls and the subsequent introduction of supply-side maturity measures.

3. 2. BREAK IN SERIES AND HARMONISATION OF THE PSD PROXY

A methodological challenge arises from a discontinuity in the measurement of public-sector digitalisation. Eurostat reports online interaction with public authorities through two related but not fully identical indicators: I_IUGOV12 for the period up to 2021 and I_IUGOV1 from 2022 onwards. To ensure consistency and construct a continuous annual proxy covering the period 2015–2024, the study applies a harmonisation procedure that combines the pre-break

and post-break series through splicing.

$$PSD_it = \{I_IUGOV12_it, t \leq 2021\} \\ \{I_IUGOV1_it, t \geq 2022\} \quad (2)$$

In practical terms, **I_IUGOV12** reflects online interactions with public authorities under the earlier Eurostat survey framework, whereas **I_IUGOV1** corresponds to the revised measurement approach introduced from 2022 onwards. Although both indicators measure citizens' online engagement with public institutions, differences in wording and scope prevent them from being considered fully identical measures. Therefore, the adjustment at the 2021/2022 transition should be interpreted as a harmonisation procedure rather than as the creation of a perfectly consistent time series. Throughout the analysis, the resulting variable is consequently treated as a harmonised usage-based proxy of public-sector digitalisation rather than a completely homogeneous indicator.

Despite this limitation, the harmonisation approach ensures temporal continuity and enables the construction of a consistent annual measure covering the entire study period. The potential effect of the methodological break is explicitly recognised as a data limitation. The resulting series is intended to capture the broader evolution of citizens' digital interaction with public authorities while acknowledging that the underlying measurement framework changed at the 2021/2022 boundary. This approach is consistent with the wider literature on digital-government measurement, which emphasises the importance of methodological transparency and comparability when applying digitalisation indicators and composite measures in empirical research (Greco et al., 2019; European Commission, 2024).

3. 3. PANEL ASSEMBLY AND DATA PREPARATION WORKFLOW

Each dataset was independently cleaned, transformed, and prepared before integration into a unified analytical panel based on a common country-year identifier. Observations lacking information on the dependent variable or the main digitalisation indicator were excluded from the respective estimation samples. This procedure follows standard practices in panel-data econometrics, particularly in fixed-effects models where identification relies on within-country variation over time. Despite a limited degree of unbalancedness, the final panel retains sufficient variation and coverage to support reliable fixed-effects estimation.

The empirical analysis starts with a two-way fixed effects (TWFE) specification:

$$\text{Growth_it} = \alpha + \beta \text{PSD_it} + \mu_i + \tau_t + \varepsilon_it \quad (3)$$

where Growth_it represents annual real GDP per capita growth, PSD_it denotes the public-sector digitalisation proxy, μ_i captures country fixed effects, τ_t represents year fixed effects, and ε_it is the idiosyncratic error term.

This specification identifies the relationship between digitalisation and economic growth based on within-country variation over time, while controlling for both time-invariant country characteristics and common temporal shocks. Country fixed effects account for persistent structural differences among EU Member States, including geographical conditions, administrative traditions, and long-standing institutional characteristics. Year fixed effects capture common EU-wide developments, such as post-pandemic recovery dynamics, macroeconomic fluctuations, and other shared shocks. Although this represents a demanding identification framework, it is appropriate for examining whether changes in public-sector digitalisation are associated with changes in growth after accounting for structural heterogeneity and common trends.

Given the observational nature of the panel and the reliance on two-way fixed-effects estimation,

the results should be interpreted as conditional associations rather than causal effects. While the model controls for unobserved time-invariant country characteristics and common year-specific influences, the possibility of omitted time-varying factors cannot be completely excluded.

All baseline specifications are estimated using country-clustered standard errors. This approach is appropriate because repeated observations within countries may exhibit serial correlation and heteroskedasticity over time. In macro-panel settings, conventional standard errors may therefore underestimate uncertainty and lead to misleading inference. Country-clustered errors provide a more reliable basis for statistical testing in this context and are widely applied in empirical panel-data research (Cameron & Miller, 2015; Millo, 2017).

3. 4. LAGGED INTERACTION SPECIFICATION AND MARGINAL EFFECTS

To examine whether the relationship between public-sector digitalisation and economic growth emerges with a time delay and varies according to institutional quality, the baseline two-way fixed-effects model is extended by incorporating lagged digitalisation measures and an interaction term with government effectiveness. This approach captures two related mechanisms.

First, the economic effects of digital public services may not appear immediately, as organisational adaptation, user adoption, and institutional adjustment require time. Second, the contribution of digitalisation to growth may depend on the capacity of public institutions to effectively implement and utilise digital reforms. In this sense, digitalisation is expected to generate stronger economic effects when supported by higher levels of government effectiveness.

Formally, the following lagged interaction model is estimated:

$$\begin{aligned} Growth_{it} = & \alpha + \beta PSD_{i,t-k} + \theta(PSD_{i,t-k} \times GE_{it}) + \\ & + \delta GE_{it} + \gamma' X_{it} + \mu_i + \tau_t + \varepsilon_{it} \end{aligned} \quad (4)$$

where i denotes EU Member States and t represents the year. The lag parameter $k \in \{1, 2\}$ refers to the one-year and two-year lag structures examined in the empirical analysis. Country fixed effects (μ_i) capture time-invariant differences between Member States, including structural institutional characteristics and long-term development patterns, while year fixed effects (τ_t) account for common EU-wide shocks and trends, such as pandemic disruptions, energy-price volatility, and inflationary pressures. The error term (ε_{it}) represents the idiosyncratic component.

The dependent variable, $Growth_{it}$, is defined as annual real GDP per capita growth:

$$Growth_{it} = \Delta \ln(GDPpc_{it_{real}}) = \ln(GDPpc_{it_{real}}) - \ln(GDPpc_{i, t-1_{real}}) \quad (5)$$

constructed from Eurostat real GDP per capita data. This transformation is widely applied in macro-panel growth models because it approximates percentage changes while reducing scale-related differences between countries.

The lagged digitalisation variable, $PSD_{i,t-k}$, represents the usage-based measure of public-sector digitalisation, defined as the share of individuals using the internet to interact with public authorities. The lag operator is applied within each country, such that $PSD_{i,t-1}$ and $PSD_{i,t-2}$ correspond to one-year and two-year lagged values of the annual digitalisation series. Government effectiveness (GE_{it}) is measured using the Worldwide Governance Indicators (WGI) estimate for Government Effectiveness. The interaction term ($PSD_{i,t-k} \times GE_{it}$) captures whether the relationship between delayed digitalisation and economic growth varies according to institutional quality.

The control vector (X_{it}) includes additional digital and macroeconomic factors: household internet access, ICT capacity measured as the share of ICT specialists in total employment,

and investment intensity measured through gross fixed capital formation as a percentage of GDP. These controls address potential omitted-variable concerns by accounting for general connectivity, digital capabilities, and a standard determinant of economic growth.

All specifications are estimated using ordinary least squares with country and year fixed effects. Statistical inference is based on heteroskedasticity-robust standard errors clustered at the country level, accounting for serial correlation and within-country dependence over time. Because lagged models require previous observations of the digitalisation variable, the first year or first two years of each country series are excluded depending on the selected lag structure. Consequently, the effective estimation sample decreases in the two-year-lag specification relative to the one-year-lag model.

Due to the inclusion of an interaction term, the coefficient of $PSD_i,t-k$ should not be interpreted as a general average effect across all institutional contexts. Instead, the estimated relationship between public-sector digitalisation and growth is conditional on government effectiveness. The marginal association is expressed as:

$$\partial \text{Growth_it} / \partial \text{PSD_i,t-k} = \beta + \theta \text{GE_it} \quad (6)$$

This formulation indicates that the growth relevance of digitalisation changes systematically with institutional quality. To improve interpretation, conditional marginal effects are evaluated at representative values of government effectiveness, such as $GE = -1$, 0 , and $+1$, or alternatively at empirical percentiles of the observed distribution. This approach translates the interaction coefficient into economically meaningful conditional relationships rather than relying only on statistical significance.

Substantively, this specification allows the analysis to assess whether public-sector digitalisation has delayed growth implications and whether these effects depend on institutional capacity. It therefore provides a more comprehensive framework than a contemporaneous main-effects model and better reflects the gradual implementation and diffusion processes associated with digital government reforms.

3. 5. ROBUSTNESS STRATEGY

The baseline TWFE estimations represent the initial stage of the empirical analysis. Several robustness extensions are introduced to evaluate whether the main findings remain stable under alternative specifications and measurement approaches.

First, the baseline model is extended by incorporating additional controls capturing the broader digital and macroeconomic environment, including ICT employment capacity, digital connectivity, investment intensity, and governance indicators. This extension reflects evidence that the economic benefits of digitalisation depend on complementary factors such as infrastructure, human capital, and institutional quality (Ding et al., 2025; Mura & Donath, 2023).

Second, lagged specifications are estimated to account for the possibility that digital public-service reforms generate economic effects only after a period of implementation, learning, and organisational adjustment. The general lagged specification is expressed as:

$$\text{Growth_it} = \alpha + \beta \text{PSD_i,t-1} + \gamma' X_it + \mu_i + \tau_t + \varepsilon_it \quad (7)$$

where $PSD_i, t-1$ represents the one-year lagged digitalisation proxy, X_it denotes the control vector, and μ_i and τ_t represent country and year fixed effects. This approach is consistent with previous research suggesting that digital government reforms typically produce delayed rather than immediate macroeconomic effects (Ha, 2024; Ding et al., 2025).

Third, the usage-based digitalisation measure is complemented with a Public-Sector Digital

Capacity Index (PSDCI) constructed from legacy dimensions of the EU eGovernment Benchmark, including user centricity, transparency, key enablers, and cross-border services. This extension distinguishes between realised user adoption and administrative capacity for delivering digital services. While usage indicators capture demand-side engagement, maturity indices provide information on supply-side institutional capability. Maintaining this distinction is important because digital service availability, user experience, and public value creation do not necessarily evolve in parallel (European Commission, 2024; Weigl et al., 2024).

Fourth, the robustness analysis applies inference procedures that account for possible cross-sectional dependence, including Driscoll-Kraay-type standard errors. This is particularly relevant in EU panels, where countries are exposed to common shocks and interconnected economic developments. These additional estimators provide a stricter assessment of whether the results remain stable under alternative assumptions about error dependence.

Finally, placebo and lead specifications are used to examine whether identified lagged relationships are consistent with plausible temporal ordering rather than reflecting coincidental trends. Together, these robustness procedures provide a systematic evaluation of whether the digitalisation-growth relationship is statistically reliable, temporally plausible and economically meaningful.

3. 6. POSITIONING WITHIN THE LITERATURE

The empirical strategy adopted in this study connects two related strands of research. The first examines the relationship between digitalisation and economic performance, frequently relying on broad digital transformation indicators such as ICT measures or composite digital economy indices (Mura & Donath, 2023; Magoutas et al., 2024). The second focuses specifically on digital government and public-sector outcomes, including administrative efficiency, governance quality, and service accessibility (Martins & Veiga, 2022; Kochanova et al., 2020; Weigl et al., 2024).

The contribution of this study lies in isolating public-sector digitalisation as a distinct growth-related mechanism within an EU panel framework. By combining a usage-based measure with a capacity-oriented index and applying fixed-effects models that control for country heterogeneity and common shocks, the analysis provides a more precise assessment of whether digital government reforms are associated with economic performance.

The methodology is intentionally conservative. Rather than if digital public services automatically generate growth benefits, the analysis examines whether such relationships remain observable after controlling for structural differences, macroeconomic shocks, institutional quality, and alternative measurement approaches. Therefore, any remaining association can be interpreted as evidence of a relationship that is not solely driven by persistent country characteristics or common European trends.

4. RESULTS AND DISCUSSION

This section presents the empirical findings progressively. The analysis begins with the most extensive and conservative specification, based on the usage-oriented measure of public-sector digitalisation covering the period 2015-2024. It then examines the alternative PSDCI measure of digital capacity for the shorter post-2020 period. Finally, the analysis investigates whether the digitalisation-growth relationship depends on institutional quality, remains significant after introducing additional macroeconomic controls, and emerges with a time lag rather than contemporaneously.

Table 2 presents the two-way fixed-effects (TWFE) estimates for the EU-27 over the period 2015-2024, with annual real GDP per capita growth ($\Delta \ln \text{GDPpc}$) as the dependent variable.

Table 2. Two-way fixed effects estimates: public-sector digitalisation and real GDP per capita growth (EU-27, 2015–2024)

Variables	(1)	(2)	(3)	(4)
Public-sector digitalisation (PSD proxy)	0.000111 (0.000266)	0.000099 (0.000278)	0.000112 (0.000272)	
Public-sector digitalisation (PSD proxy, t–1)				0.000074 (0.000292)
Households with internet access (%)		Included	Included	Included
ICT specialists (% of employment)			Included	Included
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	242	242	242	242

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$ using Eurostat SDG_08_10. PSD proxy: share of individuals using the internet to interact with public authorities (Eurostat isoc_r_gov_i, with I_IUGOV12 up to 2021 and I_IUGOV1 from 2022 onward). Internet access: households with internet access (Eurostat isoc_ci_in_h). ICT specialists: employed ICT specialists as a share of total employment (Eurostat isoc_sks_itspt, unit PC_EMP). Standard errors clustered at the country level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

Overall, the results reported in Table 2 indicate that the usage-based measure of public-sector digitalisation is not statistically associated with real GDP per capita growth in the baseline TWFE specifications. This finding motivates the subsequent analysis, which examines alternative measures of digitalisation and considers whether institutional conditions influence the relationship.

In the baseline specification (column 1), the coefficient for the public-sector digitalisation proxy, measured as the share of individuals interacting online with public authorities, is positive but statistically insignificant ($\beta = 0.000111$, $SE = 0.000266$, $p = 0.676$; $N = 242$). In practical terms, a 10-percentage-point increase in e-government usage is associated with approximately 0.11 percentage points higher growth, although the estimate is not statistically distinguishable from zero. The inclusion of household internet access as an additional control (column 2) produces virtually no change in the estimated digitalisation coefficient ($\beta = 0.000099$, $SE = 0.000278$, $p = 0.721$; $N = 242$), suggesting that within-country changes in general connectivity do not explain the absence of a measurable growth relationship. Similarly, adding ICT specialists as a measure of digital capacity (column 3) has no substantive effect on the estimated coefficient ($\beta = 0.000112$, $SE = 0.000272$, $p = 0.681$). Finally, introducing a one-year lag of the digitalisation proxy (column 4) to account for potential delayed effects also produces a small and statistically insignificant coefficient ($\beta = 0.000074$, $SE = 0.000292$, $p = 0.800$; $N = 242$).

Taken together, the results from Table 2 suggest that a usage-based indicator of public-sector digitalisation does not exhibit a robust average association with GDP per capita growth once country and year fixed effects are introduced. This result highlights the importance of examining whether alternative dimensions of digitalisation, particularly service maturity and institutional capacity, provide a more informative explanation of growth dynamics. To address this limitation, the following analysis replaces the demand-side usage proxy with a Public-Sector Digital Capacity Index (PSDCI), constructed from the legacy eGovernment Benchmark dimensions of user centricity, transparency, key enablers and cross-border services. Since these indicators are consistently available only for a shorter period, the PSDCI analysis is restricted to the 2020–2023 period.

Table 3, supported by Appendix Table B1, extends the empirical analysis using the composite

PSDCI measure. Given the limited time dimension of this panel, the PSDCI-based estimates should be interpreted as exploratory evidence regarding the relationship between public-sector digital capacity and economic growth rather than as conclusive empirical tests.

Table 3. Two-way fixed effects estimates: PSDCI (legacy eGovernment Benchmark dimensions) and real GDP per capita growth (EU-27, 2020–2023)

Variables	(1)	(2)	(3)
PSDCI (equal weights, 0–1; UC/TR/KE/CB)	0.073 (0.072)	0.067 (0.070)	
PSDCI (PCA weights, 0–1; UC/TR/KE/CB)			0.060 (0.066)
Controls: internet access, ICT specialists		Included	Included
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	108	108	108

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$ using Eurostat SDG_08_10. PSDCI (legacy) is constructed from four eGovernment Benchmark dimensions (user centrality, transparency, key enablers, and cross-border services) by min-max normalising each component across the EU-27 samples (2020–2023) and averaging the results. The alternative PSDCI uses the first principal component of the normalised dimensions and is rescaled to 0–1. Controls include household internet access and ICT specialists. Standard errors clustered at the country level are reported in parentheses.

Source: Authors' calculations

The consistently positive but statistically insignificant PSDCI coefficients suggest a directional but imprecise relationship. Given the short 2020–2023 panel, these estimates should be treated as exploratory rather than definitive. The PCA-weighted PSDCI similarly shows no statistically significant association. This lack of precision is unsurprising given the very short time series (3–4 years) and the strong common shocks captured by year fixed effects. Overall, replacing the usage proxy with PSDCI does not overturn the baseline finding: there is no robust short-run growth association detectable for either measure on the panel at hand.

Table 4 reports the results of models that incorporate institutional context via Worldwide Governance Indicators (WGI).

Table 4. Two-way fixed effects estimate with governance controls (EU-27, 2015–2023)

Variables	(1)	(2)	(3)	(4)	(5)
PSD proxy (online interaction with public authorities)	0.000245 (0.000336)	0.000303 (0.000355)	0.000237 (0.000353)	0.000265 (0.000359)	0.001346* (0.000767)
Interaction: PSD $\times$ Government Effectiveness					–0.000973* (0.000520)
Controls: internet access, ICT specialists	Included	Included	Included	Included	Included
WGI controls		GE	GE, RL	GE, RL, CC, RQ	GE + interaction
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	207	207	207	207	207

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$ using Eurostat SDG_08_10. Governance controls are WGI Estimates: Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL), and Control of Corruption (CC). Internet access and ICT specialists are included in all columns. Standard errors clustered at the country level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

Table 4 indicates that the inclusion of governance controls alone does not materially alter the

baseline findings. However, the interaction specification with Government Effectiveness suggests that the relationship between public-sector digitalisation and economic growth may be conditional on institutional context.

Columns (1) - (4) introduce the WGI governance indicators, including Government Effectiveness, Rule of Law, Regulatory Quality, and Control of Corruption, without interaction terms. The results remain consistent with the baseline models: the coefficient on the public-sector digitalisation proxy remains positive but statistically insignificant across all specifications. Thus, after controlling for country and year fixed effects, baseline digital factors, and broader governance characteristics, within-country changes in e-government usage do not appear to generate a uniform short-run association with GDP per capita growth.

A different pattern emerges in column (5), where the interaction between public-sector digitalisation and Government Effectiveness is introduced. The interaction coefficient ($PSD \times GE$) is negative and marginally significant at the 10% level, while the coefficient of the digitalisation proxy becomes positive and marginally significant. This indicates that the relationship between digitalisation and growth is not constant across institutional environments but varies according to the level of government effectiveness.

To facilitate interpretation, the marginal association between digitalisation and growth is calculated at different levels of Government Effectiveness. The results show that the relationship is stronger and statistically significant in countries with lower levels of government effectiveness, while it gradually weakens and approaches zero in countries with higher institutional capacity. For example, when Government Effectiveness is approximately $GE = -1$, representing below-average institutional quality, the one-year-lagged digitalisation measure exhibits a significant positive marginal association with growth (Table 6 and Appendix B1). At higher levels of Government Effectiveness ($GE \approx +1$), this association becomes statistically negligible.

This pattern suggests that the economic relevance of public-sector digitalisation is institutionally conditional. Digital public-service adoption may generate greater short-run benefits in environments where administrative constraints are more pronounced, as even incremental improvements in accessibility and service delivery can reduce existing frictions. Conversely, in highly effective institutional settings, the marginal contribution of additional digitalisation may be smaller because many underlying administrative barriers have already been addressed.

Table 5 confirms this interpretation is not driven by omitted investment effects.

Table 5. TWFE estimates with investment and governance controls (EU-27, 2015–2023)

Variables	(1)	(2)	(3)
PSD proxy (online interaction with public authorities)	0.000272 (0.000355)	0.000288 (0.000373)	0.001299* (0.000756)
Interaction: $PSD \times$ Government Effectiveness			−0.000920* (0.000517)
Investment (GFCF, % of GDP)	Included	Included	Included
Controls: internet access, ICT specialists	Included	Included	Included
WGI controls		GE, RL, CC, RQ	GE + interaction
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	207	207	207

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$. Investment is gross fixed capital formation as a percentage of GDP (Eurostat tec00011, P51G, PC_GDP). All specifications include country and year fixed effects. Standard errors clustered at the country level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

The results reported in Table 5 show that the governance-conditioned relationship remains largely unchanged after controlling for investment intensity. This indicates that the observed interaction pattern is not simply a consequence of differences in gross fixed capital formation across countries.

After including gross fixed capital formation as a percentage of GDP, the coefficient on the public-sector digitalisation proxy remains statistically insignificant in the non-interacted specifications. At the same time, the interaction term between public-sector digitalisation and Government Effectiveness remains close to the conventional 10% significance threshold ($p \approx 0.060$) in the interacted model. Therefore, even after accounting for investment intensity, the main conclusion remains unchanged: there is no evidence of a uniform short-run association between e-government usage and economic growth, while the relationship between digitalisation and growth continues to depend on institutional quality.

Finally, Table 6 presents the lagged specifications, which examine more directly whether the association between public-sector digitalisation and growth is conditional on Government Effectiveness over time.

Table 6. Lagged public-sector digitalisation and governance-conditioned association (EU-27, 2015–2023)

Variables	(1)	(2)
PSD proxy (t–1)	0.001624* (0.000869)	
PSD proxy (t–2)		–0.000197 (0.000892)
Interaction: PSD × Government Effectiveness (t–1 / t–2)	–0.001395** (0.000663)	–0.000771 (0.000786)
Controls: internet access, ICT specialists, investment (GFCF % GDP), GE	Included	Included
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	181	155

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$ using Eurostat SDG_08_10. PSD proxy is lagged by one and two years within the country. Government effectiveness is the WGI Estimate (GE). Standard errors clustered at the country level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

Table 6 provides the strongest evidence supporting the governance-conditioned interpretation developed throughout the analysis. The results show that the one-year lagged interaction between public-sector digitalisation and Government Effectiveness is statistically significant, whereas the two-year lag specification does not produce significant effects. This pattern supports the existence of a short-delay relationship between digitalisation and growth that depends on institutional conditions.

In column (1), based on the one-year lag of the digitalisation proxy, the interaction term $\text{PSD}(t-1) \times \text{GE}$ is statistically significant at the 5% level when using Driscoll-Kraay robust standard errors ($p \approx 0.048$), while the main coefficient of $\text{PSD}(t-1)$ is marginally significant ($p \approx 0.063$) (see Appendix C for additional robustness checks). The marginal-effect analysis demonstrates that the estimated association between lagged digitalisation and growth decreases as Government Effectiveness increases. At $\text{GE} = -1$, the marginal effect of $\text{PSD}(t-1)$ is positive and statistically significant, whereas at $\text{GE} = +1$ the estimated effect becomes close to zero (Table 6, lower panel). The two-year lag specification (column 2), however, does not show statistically significant relationships.

Overall, the lagged interaction results reinforce the interpretation that the relationship between public-sector digitalisation and economic growth is not uniform across institutional settings. Higher levels of e-government usage in period $t-1$ are associated with higher growth in period t , but this association weakens as government effectiveness increases. Consequently, the growth relevance of digitalisation appears stronger in countries with relatively lower institutional effectiveness, where improvements in digital service delivery may generate larger marginal gains.

The main robustness analyses are reported in the Appendix. Appendix Table C1 re-estimates the lagged interaction model using Driscoll-Kraay standard errors, which account for heteroskedasticity, serial correlation, and cross-sectional dependence. The main finding remains unchanged: the interaction term $PSD(t-1) \times GE$ remains statistically significant at the 5% level, while the lagged digitalisation coefficient remains marginally significant. The same table also presents a placebo lead specification, replacing $PSD(t-1)$ with $PSD(t+1)$. In this case, the interaction term becomes statistically insignificant, suggesting that the observed lagged relationship is unlikely to be driven by common trends or reverse temporal ordering.

Appendix Table C2 examines whether the findings are sensitive to alternative transformations of the digitalisation measure. Standardising the PSD proxy using a z-score produces similar inference, whereas a nonlinear logit transformation reduces the statistical strength of the interaction effect. Therefore, the interpretation remains primarily based on the original level specification, which also provides the clearest policy interpretation.

From a policy perspective, the results indicate that expanding digital public services alone may not be sufficient to generate measurable macroeconomic benefits unless accompanied by improvements in institutional capacity and implementation quality. Strengthening administrative capability, interoperability, service reliability, and digital skills alongside infrastructure investments appears essential for translating digital government reforms into productivity gains through lower administrative burdens and reduced transaction costs.

Hypotheses assessment based on empirical results:

H_1 : (Average contemporaneous association): Not supported.

H_2 : (Lagged association): Partially supported.

H_3 : (Institutionally conditioned association): Supported in the lagged interaction specification.

H_4 : (PSDCI stronger than usage proxy): Not supported under TWFE estimation with year fixed effects.

The empirical evidence reveals several important patterns. First, the usage-based measure of public-sector digitalisation does not demonstrate a statistically robust contemporaneous association with annual real GDP per capita growth in the EU-27, even after controlling for internet access and ICT capacity. This finding is consistent with the argument that the economic benefits of digital government often emerge through indirect mechanisms, including reduced administrative burdens, improved service accessibility, and enhanced business facilitation, rather than through immediate aggregate growth effects (Martins & Veiga, 2022; Kochanova et al., 2020; Arendsen et al., 2014; Hunady et al., 2025).

Second, replacing the usage-based proxy with the PSDCI measure does not produce statistically significant average effects, although the estimated coefficients remain positive. This outcome is plausible given the limited time dimension of the PSDCI panel (2020–2023) and the relatively small within-country variation in digital maturity indicators over a short period.

Third, the relationship becomes more informative once institutional conditions are considered. The interaction with Government Effectiveness demonstrates that the growth relevance

of digitalisation is heterogeneous rather than universal, with the strongest evidence emerging from the one-year lag specification. This interpretation is consistent with previous research showing that the relationship between digital transformation and economic outcomes depends on institutional quality, while e-government adoption itself is influenced by broader socio-institutional factors such as trust, accessibility, and the digital divide (Labhard & Lehtimäki, 2022; Pérez-Morote et al., 2020).

Overall, the findings support the existence of a lagged and governance-conditioned relationship between public-sector digitalisation and economic growth rather than a uniform direct effect. This conclusion aligns with the broader literature emphasising that digital government reforms generate economic value only when embedded within supportive institutional environments.

5. CONCLUSION

This study investigated the relationship between public-sector digitalisation and real GDP per capita growth in the EU-27 using country-level panel data and two-way fixed-effects models. The empirical strategy combined a usage-based indicator of e-government adoption with an exploratory Public-Sector Digital Capacity Index (PSDCI) and examined whether the relationship between digitalisation and growth is delayed and conditional on institutional quality, measured through Government Effectiveness.

The findings indicate that the usage-based measure of public-sector digitalisation does not exhibit a statistically significant contemporaneous association with real GDP per capita growth. The PSDCI-based specifications produce positive but statistically imprecise estimates, which should be interpreted cautiously due to the limited time dimension of the 2020–2023 panel. The most relevant evidence emerges from the one-year lagged interaction model, showing that public-sector digitalisation is positively associated with growth in environments with lower levels of Government Effectiveness, while this relationship becomes weaker as institutional effectiveness increases.

These results suggest that public-sector digitalisation should not be viewed as an automatic short-term driver of economic growth. Rather, its economic relevance depends on the institutional environment in which digital reforms are implemented. Expanding digital public services alone is unlikely to generate substantial growth effects unless accompanied by sufficient administrative capacity, effective interoperability, implementation capability, and reliable service delivery mechanisms.

Several limitations should be acknowledged. The construction of the harmonised Eurostat digitalisation proxy introduces measurement uncertainty due to the underlying series break, while the PSDCI analysis is restricted by the short post-2020 observation period. Furthermore, annual GDP per capita growth may not fully capture the short-term economic effects of public-sector digital reforms, which often operate through gradual improvements in administrative efficiency and service quality. Future research could address these limitations by incorporating longer maturity-based digital government indicators, administrative micro-level data, or regional and sectoral performance measures to better identify the mechanisms through which public-sector digitalisation contributes to economic outcomes.

Appendix A

Table A1. Full list of variables used in the study

Variable name	Code / symbol	Definition	Source
Real GDP per capita	GDPpc_real_it	Real GDP per capita at constant prices, used as the base macroeconomic outcome variable.	Eurostat, SDG_08_10
Log real GDP per capita	ln(GDPpc_real_it)	Natural logarithm of real GDP per capita.	Constructed from Eurostat SDG_08_10
Real GDP per capita growth	Growth_it	Annual growth of real GDP per capita, calculated as $\Delta \ln(\text{GDPpc_real_it}) = \ln(\text{GDPpc_real_it}) - \ln(\text{GDPpc_real_it-1})$.	Constructed from Eurostat SDG_08_10
Public-sector digitalisation proxy	PSD_it / psd_proxy	Share of individuals using the internet to interact with public authorities; harmonised series built from Eurostat indicators before and after the methodological break.	Eurostat, isoc_r_gov_i
Pre-break digital interaction series	I_IUGOV12	Internet use: interaction with public authorities during the last 12 months, used for the pre-2022 period.	Eurostat, isoc_r_gov_i
Post-break digital interaction series	I_IUGOV1	Internet use: interaction with public authorities during the last 12 months, used from 2022 onward.	Eurostat, isoc_r_gov_i
One-year lag of PSD	PSD_i,t-1	One-year lag of the public-sector digitalisation proxy.	Constructed from psd_proxy
Two-year lag of PSD	PSD_i,t-2	Two-year lag of the public-sector digitalisation proxy.	Constructed from psd_proxy
Household internet access	Internet_it / internet_access	Share of households with internet access.	Eurostat, isoc_ci_in_h
ICT specialists	ICT_it / ict_spec	Employed ICT specialists as a share of total employment.	Eurostat, isoc_sks_itspt
Government effectiveness	GE_it / wgi_ge	Estimate of Government Effectiveness, capturing perceptions of the quality of public services, civil service, policy implementation, and government credibility.	Worldwide Governance Indicators, GE.EST
Rule of law	RL_it / wgi_rl	Estimate of Rule of Law.	Worldwide Governance Indicators, RL.EST
Control of corruption	CC_it / wgi_cc	Estimate of Control of Corruption.	Worldwide Governance Indicators, CC.EST
Regulatory quality	RQ_it / wgi_rq	Estimate of Regulatory Quality.	Worldwide Governance Indicators, RQ.EST
Investment intensity	Inv_it / gfcf_gdp	Gross fixed capital formation as a percentage of GDP.	Eurostat, tec00011
PSDCI legacy, equal-weighted	PSDCI^EQ_it	Composite Public-Sector Digital Capacity Index based on the legacy eGovernment Benchmark dimensions, aggregated using equal weights.	Constructed from eGovernment Benchmark legacy indicators

Variable name	Code / symbol	Definition	Source
PSDCI legacy, PCA-weighted	PSDCI ^{PCA} _it	Alternative Public-Sector Digital Capacity Index based on PCA-derived weights.	Constructed from eGovernment Benchmark legacy indicators
User centrality	e_gov_1_uc / UC_it	Extent to which public digital services are user-oriented and easily accessible.	eGovernment Benchmark
Transparency	e_gov_2_tr / TR_it	Degree of transparency of digital public services and related administrative information.	eGovernment Benchmark
Key enablers	e_gov_3_ke / KE_it	Availability of enabling digital infrastructure such as eID, eDocuments, authentic sources, and digital post.	eGovernment Benchmark
Cross-border services	e_gov_4_cb / CB_it	Availability and usability of digital public services across borders.	eGovernment Benchmark
Interaction term: PSD × GE	PSD _{i,t-k} × GE_it	Interaction capturing whether the association between lagged public-sector digitalisation and growth depends on government effectiveness.	Constructed from psd_proxy and wgi_ge
Interaction term: PSDCI × GE	PSDCI_it × GE_it	Interaction capturing whether the association between public-sector digital capacity and growth depends on government effectiveness.	Constructed from PSDCI and wgi_ge

Source: Authors' compilation based on Eurostat, Worldwide Governance Indicators, and European Commission eGovernment Benchmark data

Appendix B

Table B1. Two-way fixed effects estimates: PSDCI (eGovernment Benchmark) and real GDP per capita growth (EU-27, 2020–2022)

Variables	(1)	(2)	(3)
PSDCI (equal weights, 0–1)	0.038 (0.053)	0.026 (0.060)	
PSDCI (PCA weights, 0–1)			0.024 (0.056)
Controls: internet access, ICT specialists		Included	Included
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	81	81	81

Notes: Dependent variable: annual real GDP per capita growth, measured as $\Delta \ln(\text{Real GDP per capita})$ using Eurostat SDG_08_10. PSDCI is constructed from eGovernment Benchmark dimensions (User centrality, Transparency, Key enablers, Cross-border) by min–max normalising each component over the EU-27 sample and averaging them (equal weights). An alternative PSDCI uses the first principal component of the normalised dimensions (PCA weights), rescaled to 0–1. Controls include household internet access (Eurostat isoc_ci_in_h) and employed ICT specialists as a share of total employment (Eurostat isoc_sks_itspt). All specifications include country and year fixed effects. Standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations

Appendix C

Table C1. Placebo test and Driscoll–Kraay inference for Table 6

Variables	(A) Lagged PSD (t–1)	(B) Placebo lead PSD (t+1)
PSD term	0.001624* (0.000875)	0.001041* (0.000555)
Interaction with GE	–0.001395** (0.000704)	–0.000198 (0.000566)
Controls + FE	internet access, ICT specialists, investment; country & year FE	internet access, ICT specialists, investment; country & year FE
Observations	181	181

Notes: Both specifications are TWFE models estimated with country and year fixed effects. Reported standard errors are Driscoll–Kraay. The placebo specification replaces the lagged PSD term with its one-year lead.

Source: Authors’ calculations

Table C2. Robustness to transformation of the PSD proxy (EU-27, 2015–2023)

Variables	(0) Original	(1) Logit share	(2) Z-score	(3) Z-score logit
PSD term (t–1)	0.001624* (0.000869)	0.025659 (0.018015)	0.032520* (0.017394)	0.025433 (0.017856)
Interaction with GE (t–1)	–0.001395** (0.000663)	–0.021287 (0.013422)	–0.027932** (0.013268)	–0.021100 (0.013304)
Controls + FE	internet access, ICT specialists, investment, GE; country & year FE	internet access, ICT specialists, investment, GE; country & year FE	internet access, ICT specialists, investment, GE; country & year FE	internet access, ICT specialists, investment, GE; country & year FE
Observations	181	181	181	181

Notes: Dependent variable is annual real GDP per capita growth. All specifications correspond to the Table 6 lagged interaction model ($k = 1$) and include country and year fixed effects with standard errors clustered by country.

Source: Authors’ calculations

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