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DIGITALIZATION AND GOVERNMENT EFFECTIVENESS

EMPIRICAL EVIDENCE FROM GLOBAL PANEL DATA

NAZARBAYEV
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EMPIRICAL EVIDENCE FROM GLOBAL PANEL DATA

Master's Thesis

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DECLARATION OF AUTHORSHIP

I hereby declare that this thesis is my own original work and has been written independently. All sources of information and materials used in the preparation of this thesis have been properly acknowledged and cited and are included in the list of references.

Dina Dybyspayeva

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(Signature)

DECLARATION OF GENERATIVE AI USE

During the preparation of this work, the author used generative AI tools to brainstorm ideas, discuss analytical approaches, and review the manuscript for consistency and clarity. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the published work.

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ABSTRACT

Digital transformation is increasingly promoted as a pathway to institutional modernization, with governments worldwide investing heavily in e-government infrastructure. However, evidence about the impact of technological progress on governance is rather mixed. Current research on this topic mainly relies on cross-sectional data that confound cross-country characteristics with causal mechanisms, making it difficult to understand the internal connection between technological development and governance.

In this study, the hypothesis of interest is to examine if a greater degree of digitalization of governmental institutions is related to an improvement in government effectiveness, applying a global dataset of 172 countries from 2000 to 2024. The level of digitalization is measured by the E-Government Development Index (EGDI), and government effectiveness (GE) is measured by the Government Effectiveness Index collected by the World Bank. A two-way fixed effects model leverages the within-country variation over time while accounting for time-invariant unobserved heterogeneity and exogenous shocks.

The results reveal that there exists a positive and statistically significant effect of the development of e-government on the effectiveness of the government, although the magnitude of the coefficient falls sharply from 3.401 using pooled OLS to 0.551 using the preferred regression approach. The effects are not immediate; they occur mainly after a lag period of two years to four years. The institutional persistence coefficient of around 0.75 suggests that the effect of governance is historically rooted.

Overall, results suggest that the digital revolution affects governance in an amplifying manner; hence, it is not about transforming institutions but amplifying their abilities.

Keywords: digitalization; government effectiveness; two-way fixed effects; e-government; institutional persistence; panel data

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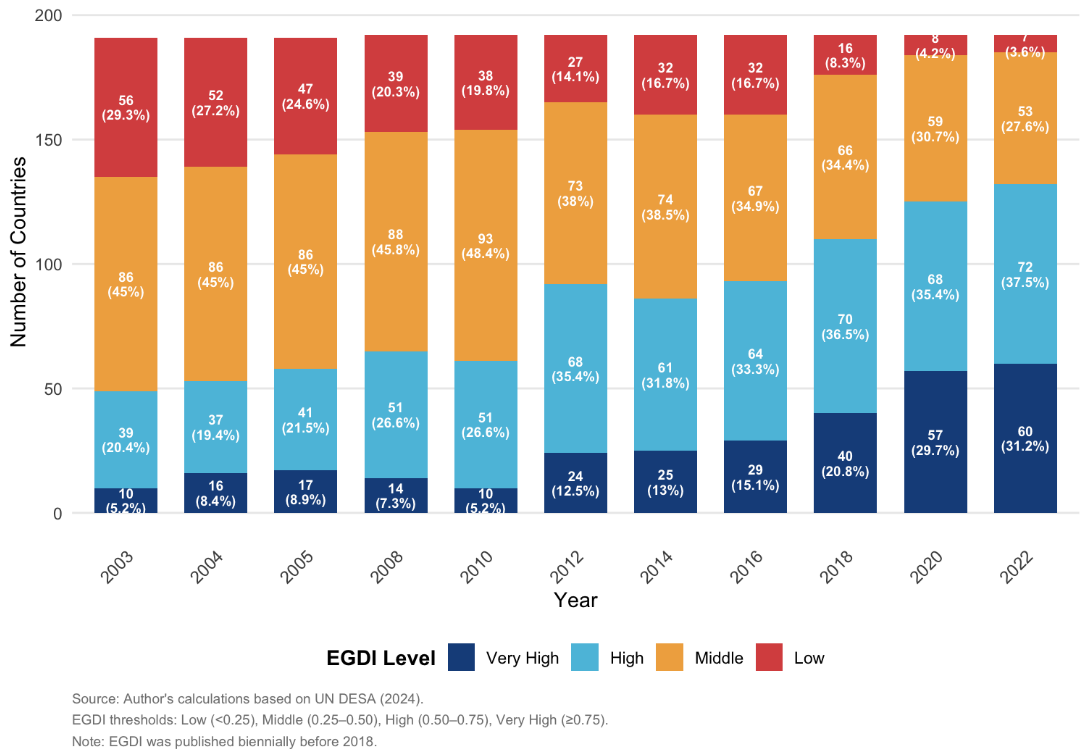
Chapter 1. INTRODUCTION

Today, digital infrastructure becomes an important part of governmental operations. It is widely used by states in order to automate their administrative procedures and make them more efficient and transparent (Ndou, 2004; World Bank, 2024). In this respect, digital transformation is seen as a process of institutional modernization rather than a technological one. International organizations encourage states to engage in the process of digital transformation to improve their administrative capacity. As a result governments respond to these initiatives by increasing investments in digital infrastructure (Androniceanu & Georgescu, 2023; United Nations Department of Economic and Social Affairs, 2024).

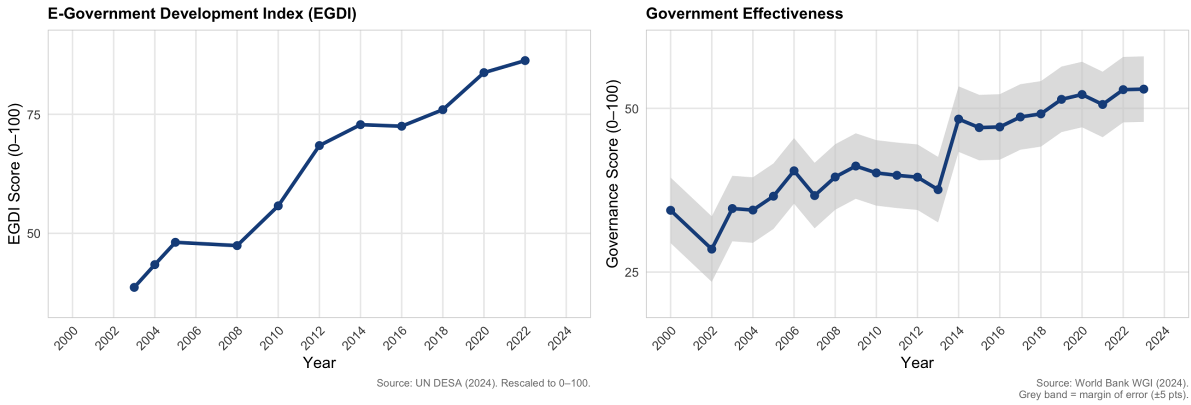
Figure 1.1: Number of Countries by EGDI Level, 2003–2024



Digital transformation plays a vital role in public sector reforms. Development of data systems and online service platforms reduces friction costs both for individuals and companies. United Nations Department of Economic and Social Affairs (2024) data shows gradual rise in the number of states that have reached the advanced level of development of their e-governance infrastructure over the past decade (Figure 1.1). From the Figure 1.1 it is easily observed that the proportion of countries in the Very High category has grown from 5% in 2003 to 40% in 2024, while the number of Low EGDI countries has fallen from 57 to 11.

On the other hand, increased availability of digital services does not always imply improved government performance. Although digital technologies can help in providing greater access to information and making procedures more efficient, good governance is dependent on other aspects, such as organizational capacity, administrative legitimacy, and consistent policy implementation too (Fukuyama, 2013). This poses an analytical dilemma: how to separate technological growth from institutional development? The idea that investment in digital technologies leads to improvements in governance without any further consideration has been referred to as "technocraticism" (Zou et al., 2023). They argue that this strategy dominates the field despite being built on a weak foundation. It is seen as success can only be achieved through alignment between the three sectors rather than technological innovation alone.

Figure 1.2: Kazakhstan: Digital Expansion and Government Effectiveness, 2000–2024



This tension is particularly visible in the context of rapid digital transformation. Kazakhstan offers a compelling illustration. Over the past two decades, Kazakhstan has invested heavily in digital public infrastructure, rising from 28th to 24th place in the UN E-Government Development Index between 2022 and 2024. It achieved an EGDI score of 0.9009 and ranked first among all landlocked countries globally and placing in the top 10 worldwide on the Online Services Index (United Nations Department of Economic and Social Affairs, 2024). Yet governance outcomes have not kept pace with this digital expansion. As shown in Figure 1.2, Kazakhstan's EGDI nearly doubled between 2003 and 2022, rising from approximately 0.38 to 0.90 on the 0-1 scale, while its Government Effectiveness score improved only modestly over the same period from 0.15 -0.778 in 1996 to 0.15 in 2024 on the WGI scale (World Bank, 2024), remaining only marginally above the global average of 0.05. This divergence between digital capacity and institutional outcomes raises the central empirical question of this thesis: does rapid expansion of e-government infrastructure translate into measurable improvements in government effectiveness, or does it primarily reflect surface-level modernization that leaves deeper institutional structures unchanged?

To address this question, this thesis examines whether increases in digitalization are associated with subsequent changes in government effectiveness using a global panel dataset of 172 countries over the period 2000–2024. The analysis focuses on within-country variation over time. This allows for a more precise evaluation of how changes in digitalization relate to changes in governance outcomes, while controlling for persistent institutional characteristics that would otherwise confound cross-country comparisons.

Contributions of this study can be made along three axes. First, this paper expands the panel specification of Wandaogo (2022) to include a global exhaustive dataset of 172 countries spanning the period from 2000 to 2024, thus increasing both time-series and cross-national coverage compared to other papers on the topic, the majority of which employ shorter time horizons or country sub-samples. Second, the study incorporates an explicit test of institutional persistence by estimating the lagged dependent variable specification, thereby providing a quantifiable assessment of the extent to which governance persistence limits the visible effect of digitalization. Third, the study contributes to the understanding of the timing and dynamics of the digitalization-governance relationship by adopting distributed lag models, which demonstrate that the effects of the e-government development manifest themselves in two to four years and not immediately. Even though the empirical literature increasingly emphasizes positive relationships between digitalization and quality of governance, most of these results are derived from cross-sectional analysis, confounding cross-country differences with the effects of the digitalization process itself. By exploiting longitudinal variation and employing a two-way fixed effects framework, this study isolates within-country dynamics and provides a more conservative and temporally grounded estimate of the relationship.

In addition, the analysis explicitly addresses two key challenges that recur throughout this literature. Firstly, persistence means that governance results are highly influenced by historical processes, thus potentially diminishing the effect of digital transformations in the short term (Acemoglu et al., 2008). Secondly, endogeneity is related to the potential presence of reverse causality. If better governments are better suited to embrace digital technologies, a two-way relationship emerges that cannot be captured through aggregated correlations (Cunningham, 2021). As pointed out byCunningham (2021), the optimal behavior of humans and institutions implies that decisions are made based on expectations, therefore leading to endogenous variables that do not reflect causal relations. In order to deal with these problems, the methodological approach includes lagged models, dynamic models, and reverse causality tests.

This thesis' central question can be summarized as follows: Is there any associaiton between an increase in digitalization in a country and improvement in the effectiveness of governance? Three aspects are investigated empirically: the presence of a within-country correlation between digitalization and governance, the dynamics of such a correlation over time, and differences between low-, middle-, and high-income countries.

The remaining chapters of the dissertation are organized as follows. Chapter 2 gives a review of the literature, emphasizing the mechanisms, heterogeneity, and transformation-versusamplification distinction. Chapter 3 describes the data used and the methodology, particularly highlighting the use of panel data and econometrics. Chapter 4 details the empirical findings, which include baseline estimations, dynamic effects, heterogeneity effects, and reverse causality tests. Chapter 5 provides discussion of the findings within the context of previous literature. Chapter 6 concludes the thesis.

Chapter 2. LITERATURE REVIEW

The current literature review seeks to explore the dynamics of the connection between digital governance and institutional performance within the lens of institutional economics and causal inference. Instead of framing digitalization as a technical phenomenon, this paper will look at its intersection with the existing institutionality, elite behavior, and the limitations of measurement. The ultimate goal is to advance from simply finding connections to establishing the factors that may allow digitalization to impact the governance process, as Cunningham (2021) notes, in ways that are far from obvious.

2.1 Institutional Foundations: Persistence and Elite Resistance

It is important, before considering an empirical discussion on governance reform, to define what institutions are and to understand why they are so resistant to change. As defined by North (1990), institutions are the rules of the game under which interactions occur. Their role in shaping the incentives faced by individuals and governments is thus crucial.

Persistence is one of the major attributes of institutional systems. As argued by Acemoglu et al. (2008) and Mustofa et al. (2025), societies follow distinct development paths at certain historical points. Thus, this development takes place under strong persistence. This means that the institutional setting today is strongly linked to its historical roots. Therefore, change happens gradually and incrementally and is filtered through the current system of institutions.

Crucially, persistence is not merely a result of inertia in institutions. Rather, it is a product of active reproduction through the conduct of the elites. There are vested political and economic interests which benefit from the existing institutional set-up and have much to lose if any restructuring threatens their privileged position. In this sense, institutional persistence is not only an exogenous feature of the past, but also an endogenous result of repeated interaction. Cunningham (2021) argue that economic theory implies that actions are endogenous, as people optimize their behavior according to expected outcomes, including the adoption of new technologies.

There are methodological implications. The ceteris paribus condition, holding other relevant factors equal, is an indicator of credible causal analysis (Wooldridge, 2020). But the demand is very difficult to satisfy in institutional settings. As Cunningham (2021) points out, credible causal estimates require deep knowledge of the data-generating process and the behavioral and institutional mechanisms through which the variables of interest were actually produced. Absent such knowledge, even sophisticated empirical designs may misattribute structural patterns to the reforms under investigation.

In light of these considerations, it becomes clear that digitalization cannot be analyzed using the assumptions of an exogenous technological shock. The effects of digitalization are inherently conditional on the institutional context within which it operates, and that context, in turn, is influenced by strategic actors who may strategically utilize digitalization in a manner that preserves rather than disrupts the status quo.

2.2 Channels of Influence: Theoretical Mechanisms and Empirical Conditions

Three pathways through which digitalization could positively impact governance outcomes are usually cited in the literature. Yet, all three channels depend on empirical assumptions that are seldom studied in enough detail. The transition from abstract mechanisms to empirical recommendations needs the shift from stabs in the dark to identification methods based on institutional understanding, proposed by Cunningham (2021).

Administrative efficiency. There is evidence that digitalization increases institutional bodies' efficiency. According to Zou et al. (2023), digital service delivery development makes decision-making faster and thereby reduces the rational risk of errors. Additionally, Wandaogo (2022) points out that digitalization leads to a reduction in costs associated with information storage, duplication, and transmission. Consequently, the channel ensures increased state capacity without a proportional increase in resources. Nonetheless, the independence of technology choice from unobserved factors affecting the governance-performance link, as stated by Cunningham (2021), seems unlikely in cases when individuals take decisions that ensure their personal gain. More precisely, Yang et al. (2024) emphasize that the digital state is a fallacy. In reality, back-office reforms associated with administrative efficiency tend to attract less attention compared to front-office variables (Yang et al., 2024). In the meantime, according to Zou et al. (2023), digital technologies cannot be a way to promote democracy without an open governance system because, in any other case, digitalization will simply move the center of corruption

Information accessibility and transparency. According to Montes et al. (2019), transparency addresses principal-agent problems by improving the traceability of governmental operations. This contributes to higher accountability and the reduction of corruption. Additionally, as mentioned by Zou et al. (2023), digitalization can resolve issues associated with information distribution and ensure a wider range of influence for public control. However, transparency will contribute to accountability only when individuals have access to and can comprehend the data made available to them. It becomes evident that another important covariate is digital literacy. According to Diakite and Wandaogo (2024), neglecting the importance of this covariate will result in superficial interactions with the instruments of digital transparency, which will reinforce social discrimination instead of addressing it. Ignoring this variable means that researchers will analyze the behavior of the digitally literate elite instead of the population in its entirety (as described by Cunningham (2021)).

Citizen engagement. According to Diakite and Wandaogo (2024), Mustofa et al. (2025), and Wandaogo (2022), digital media make it easier for citizens to participate politically as well as reduces any geographical or environmental constraints on their participation. In theory, the use of such media is expected to improve the responsiveness of governments to citizen demands. Nevertheless, the condition of zero conditional means, which assumes no correlation between the error term and the choice of media for communication, may not apply in cases where engagement strategies have been systematically biased by socioeconomic factors. As noted by Zou et al. (2023), even where there are effective services, people who lack digital literacy continue to prefer face-to-face engagements.

For each of the three pathways, the main issue is the same. While the theory provides a coherent mechanism, the empirical requirements to meet the theoretical requirements are stringent and context-specific. This aligns with the trend in the literature as a whole in that it shows clear positive connections between digitalization and governance yet fails to establish robust causal relationships.

2.3 Empirical Evidence: Cross-Sectional Disparities and Null Effects

There is a substantial body of research that has found a positive relationship between digitalization and the efficiency of governments. According to Androniceanu and Georgescu (2023), Yang et al. (2024), and Zou et al. (2023), there have been statistically significant advancements in various governance measures due to digital growth in different regions and countries.

However, such an explanation should be handled with diligence. As explained by Zou et al. (2023), most papers employ cross-sectional data and cannot account for time dynamics and unobservables. Leszczensky and Wolbring (2022) explain that panel research uses temporal variation within units and excludes fixed heterogeneity over time. Cross-sectional results cannot accomplish that goal, capturing cross-country structural variations more likely than dynamic within-country developments, leading to inflated coefficients.

The central issue lies in the identification strategy. According to Cunningham (2021), correlation in observational data does not necessarily imply causality due to choice endogeneity. Variables represent choices by agents. This implies that any associations between the variables depend on potential outcomes. In the absence of exogenous shocks, a causal conclusion is implausible. To identify a causal effect, one needs random assignment via either natural experiments or strong quasi-experiments.

The context complicates understanding further. Zhao and Du (2025) find that there is a threshold point in the impact of digital governance on institutional outcomes. Digital technology would only have a positive effect on institutions if countries managed to build a minimum quality of institutional framework, particularly the rule of law and social stability. Even below such a critical point, technology can exacerbate institutional challenges. Olumekor et al. (2025) find a similar result. They identified that digital tools increase participation where there is good capacity for administration and low institutional fragility.

At the same time, there is meaningful evidence of null or superficial effects. Supporting the findings of O'Neill (2009) and Yang et al. (2024) explain that e-government increases access to services in some highly institutionalized settings with little impact on the quality of governance itself. This problem is attributed by Zou et al. (2023) to a focus on technological solutions without further organizational changes. OECD (2024) experts make similar points, stressing that the difference between simple adoption of technologies and adoption of meaningful reforms is very important.

As Wandaogo (2022) notes, there is another factor in developing countries where digitization efforts face challenges. It is their dependence on traditional administrative methods based on paper processes. This suggests that it is bureaucratic absorptive capability, rather than the possession of technological means, that becomes a limiting factor for success.

Thus, while the body of evidence is inconclusive in this respect, there is some methodological heterogeneity in the current state of empirical work on the issue. Positive results have been obtained via cross-sectional approaches but disappear upon employing panel data and fixed effects.

2.4 Measurement: Deconstructing Index Bias

Any empirical study of digitalization and governance relies heavily on the way in which relevant variables are implemented. The dependent and independent variables are created through composite indices, some elements of which depend on perception-based data. These methodological issues influence the interpretation of results and constrain their scope. Scott Cunningham (2021) stresses the need to ensure that empirical analysis is based on credible identification and not agreement with the expected outcomes. Perception-based measures make it challenging to achieve this aim. Such indicators may capture the observer's belief rather than the reality of the institution. In the view of Al-Marhubi (2004), following Isham et al., governance is hard to quantify objectively because of strong pre-existing perceptions about its nature.

For the dependent variable, Garcia-Sanchez et al. (2013), Mustofa et al. (2025), and Zhao and Du (2025) point out several limitations of the World Governance Indicators (WGI), including lack of transparency, weak theoretical basis and comparability over time. Furthermore, Al-Marhubi (2004) finds that the dimensions of WGI are highly correlated, with coefficients very close to 0.94. This raises the possibility that the index is a single latent construct rather than different dimensions of governance. This issue is mitigated by concentrating the analysis on the Government Effectiveness component. The perception-based nature of the measure remains a constraint.

In terms of the key independent variable, Zou et al. (2023) argue that indices like the EGDI focus on front-end digital services and are less able to capture internal administrative transformation. Yang et al. (2024) argue that the idea of e-government as a collective whole conceals variation across sectors. But changes in core administrative functions such as finance can have a larger impact than service level upgrades, and aggregate indices do not differentiate between them. Zhao and Du (2025) also note that these measures are based on expert and business perspectives, not user experience.

These limitations have direct econometric implications. Measurement error in the independent variable leads to attenuation bias, which reduces estimated coefficients toward zero. As a result, the fixed-effects estimates reported here likely understate the true relationship between digitalization and government effectiveness.

2.5 Identification Challenges and Panel Strategy

The issue of identification, as the process through which it is possible to isolate a causal effect through observational data, is more than just a technical question. Cunningham (2021) frames identification as an epistemic limitation on what can be known from data. As per Angrist and Pischke (2009), an identification strategy is a way of making use of observational data to simulate the conduct of an experiment. The credibility of an approach depends not on data access but on theoretical and institutional considerations.

Cunningham (2021) rudder analogy describes the nature of the challenge well. A sailor moves the rudder to counteract winds, making the boat move in a straight path despite the position of the rudder. To an unknowledgeable observer, it will seem like the rudder does nothing. But in truth, the rudder works consistently. However, its influence is concealed due to endogenous control mechanisms. In such a scenario, the role of the government would be that of the sailor, digital investments that of the rudder, and the wind an unobserved institutional factor. With weak governance systems, governments will have to increase their investments in technology as a way of addressing any shortcomings, whereas governments with good governance levels

There are three major endogeneity problems in this context. First, reverse causality: efficient governments may be able to enforce reforms, hence creating a reciprocal relationship between the two. Second, omitted variable bias: time-varying factors, such as reform capability, bureaucracy, and external shocks, might influence both digitalization and governance. Finally, policy endogeneity: governments might choose to enforce reforms in light of their existing institutional framework.

Dealing with these challenges calls for a credible approach to identification through instrumental variables. According to Angrist and Pischke (2009), there are two necessary conditions for an instrument to be valid: relevance and exclusion. However, meeting both of these criteria poses a challenge in a macro-institutional environment. Moreover, invalid and weak instruments generate further bias and are even more misleading than initial estimates.

Another issue that arises is Nickell bias. According to Nickell (1981), when the dependent variable in a fixed-effects model is lagged, it leads to a correlation between the regressors and the error term following the within transformation. Leszczensky and Wolbring (2022) establish this finding as well. While the transformation subtracts unit means from both sides of the equation, the lagged dependent variable continues to correlate mechanically with the transformed error term. As such, it violates the assumption of strict exogeneity. In the context of this research, given a time dimension of about ten to eleven observations, the problem exists but is not too severe.

Cunningham (2021) clarifies the difference between the residual, which is observable, and the error term, which includes all unobservable determinants of the dependent variable. According to Wooldridge (2020), the key issue in econometrics is dealing with the unobserved components. No data set can substitute for theory in deciding what goes into the error term and its relationship with the regressors.

2.6 Transformation vs. Amplification

An important question raised in this literature is whether digitalization leads to a fundamental transformation of the governance systems or serves to strengthen the existing institutional structures. The transformation perspective, which can be identified with the arguments made by Androniceanu and Georgescu (2023) among others, sees digitalization as having the potential to transform the governance process and increase state capacity. According to this theory, digitalization involves transforming existing institutional equilibria through an increase in state capacity. The argument behind this theory stems from comparative statics as described by Cunningham (2021). Comparative statics refers to the theoretical description of the cause-and-effect relationship that is necessarily ceteris paribus in nature.

Amplification theory provides a more conservative explanation. As explained in Labhard and Lehtimäki (2022) the wider context and institutional framework is an amplifier for the possible outcomes of digitalization in which technologies are only an enhancement of the existing system and not something radically different. Notably, however, this view has been developed further by Zou et al. (2023) in that they have highlighted the fact that amplification is not always beneficial. In cases where governance mechanisms are characterized by lack of transparency and are aimed at control, technologies can amplify these processes. In other words, it may make the authoritarian system stronger while failing to improve services.

The most elaborated theoretical formalization of this boundary from the perspective of transformation and amplification of technologies is given by Zhao and Du (2025). Specifically, these researchers suggest the notion of an institutional threshold beyond which digitalization produces a positive effect on the functioning of the governance framework and, as a result, leads to a digital dividend. Below this threshold, technology can merely enhance the contradictions of a poor governance mechanism.

The empirical evidence discussed throughout this chapter is more consistently supportive of the amplification view. The persistence of governance outcomes (estimated at approximately 0.75 in the dynamic specifications of this study) suggests institutional inertia is the dominant force shaping effectiveness, with digitalization operating as a secondary reinforcing mechanism rather than a primary driver of change. This framing informs the interpretation of all results presented in the chapters that follow.

Chapter 3. METHODOLOGY

3.1 Research Design

This study uses a panel data framework to examine the relationship between digitalization and government effectiveness. Cross-country correlations often reflect structural differences rather than causal relationships (Acemoglu et al., 2008; Cunningham, 2021). As a result, comparing countries at a single point in time may lead to misleading conclusions.

Instead, the analysis focuses on changes within countries over time. This approach allows the study to assess whether increases in digitalization are associated with improvements in government effectiveness within the same country. By doing so, it controls for persistent national characteristics that are difficult to observe directly.

However, this design does not fully resolve identification challenges. Time-varying factors and policy choices may still influence both digitalization and governance outcomes. Therefore, the results should be interpreted as conditional relationships rather than causal effects.

3.2 Variables and Data Description

The dataset includes 172 countries over the period 2000˜2024. All variables are obtained from international sources to ensure consistency and comparability across countries and over time. The panel is unbalanced due to differences in data availability across indicators and years, resulting in approximately 2046 country-year observations used in the baseline regression, compared to the maximum of 4748 possible observations. The primary reason for this reduction is the publication frequency of the EGDI, which was issued biennially from 2003 onward and only became annual after 2018, limiting the number of years for which digitalization data are available.

Dependent Variable: Government Effectiveness

Government effectiveness is assessed based on the Government Effectiveness (GE) measure, one of the six sub-indicators of the Worldwide Governance Indicators (WGI) produced by the World Bank (Kaufmann et al., 2010). The six WGI categories are Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. In this study, only the GE sub-indicator was utilized, while the aggregate WGI indicator was not used. The GE measure is an index that reflects opinions on the effectiveness of public services, the competence and autonomy of the civil service, and the reliability of the government in implementing policies. This index is calculated based on the information obtained from several sources, including experts, firms, and non-governmental organizations (NGOs), through an Unobserved Components Model (UCM), which assigns different weights to each source depending on how well it correlates with the core aspect of governance (Kaufmann & Kraay, 2024). The scores generated by the approach vary within the range of -2.5 to 2.5 *, with the score increasing for higher government effectiveness. One key problem with using this approach in evaluating governance quality is that it is based on perceptions and not directly obtained from administrative records. It follows that the index would have limited capability to respond immediately to developments in institutional effectiveness. Nevertheless, despite such weaknesses, the GE index is still considered the most popular tool used in evaluating governance quality empirically.

[1]

Primary Independent Variable: E-Government Development Index

Digitalization will be quantified through the E-Government Development Index (EGDI) that has been put together by the United Nations Department of Economic and Social Affairs (UN DESA 2024). The EGDI is a composite index taking values from 0 to 1 and consisting of three sub-indices. The Online Services Index (OSI) assesses the coverage and effectiveness of government online services. The Telecommunication Infrastructure Index (TII) gauges the development stage of national telecommunication infrastructure. Lastly, the Human Capital Index (HCI) accounts for the amount of human capital that can be utilized for digital interaction. What is crucial, though, is that EGDI quantifies e-government development rather than national digital transformation as such. This implies that results generated by the study have to be seen as reflecting upon the connection between government digitalization and outcomes of governance, but not effects of overall national digitalization on other aspects of societal performance. A major limitation of the EGDI is its focus on measuring front-end service delivery access, which fails to take into account the back-end digital transformation within the bureaucracy, which could be closer to what really matters for administrative effectiveness (Yang et al., 2024; Zou et al., 2023). In addition, the equal importance attributed to all the sub-factors of EGDI assumes that the three elements of e-government maturity—online services, infrastructure, and human capital—are of equal importance, which might not always be true in different institutions. Furthermore, because the index was only published every two years up until 2018, the availability of annual data observations was limited.

Control Variable

The baseline model considers four control variables that vary over time, in line with the

[1]*The World Bank revised the WGI methodology in 2025, introducing an absolute 0–100 scale anchored to fixed benchmark countries. This study uses the original standardized scores ranging from -2.5 to 2.5, consistent with the data employed throughout the empirical analysis and with comparable studies in this literature (Kaufmann & Kraay, 2024; Wandaogo, 2022). Historical estimates have been recalculated by the World Bank to ensure full comparability over time.

method used by Wandaogo (2022). This includes factors that relate to economic growth, institutions, and infrastructure. These factors can have an impact on both the development of e-government and governance outcomes. Therefore, excluding them could result in overestimating the role of digitalization.

The natural log of GDP per capita is used as a proxy for the country's development level since developed economies generally have a higher fiscal capacity, better bureaucracy, and stronger incentives to spend on their digital infrastructure and governance reforms (Acemoglu et al., 2008). This variable is retrieved from World Bank (2024) and calculated in constant US dollars before taking the natural log. A possible problem with including this variable might be endogeneity since good governance leads to faster economic growth. However, the inclusion of fixed effects controls for the time-invariant part of the effect, while using lags of the independent variables helps eliminate simultaneity.

The log of population is used to control for variations in the size of countries, which could potentially have an impact on both the complexity of governance and the viability of using digital technologies for service delivery. Larger countries experience more difficulties in terms of administering public services and might require bigger investments in their digital infrastructure in order to reach the same level of efficiency. The data is provided by World Bank (2024), and log population shows only weak (negative) correlations with the governance indicators, as seen in Table 3.2.

Political stability is incorporated as one of the controls of the wider institutional and security setting within which governance and digitalization function. Conflict and politically unstable countries will inevitably suffer from interruptions both in administrative processes and in investments related to the development of their digital infrastructure. Thus, it is necessary to isolate such effects from the effect of development of e-governance systems. The political stability variable is derived from the Political Stability and Absence of Violence sub-index in the Worldwide Governance Indicators (Kaufmann et al., 2010). As important as it is to stress that political stability is a separate WGI sub-index, which cannot be confused with government effectiveness, a sub-index serving as the dependent variable in this research. Despite the fact that the two sub-indexes measure completely different aspects of governance, the former being related to political stability while the latter is related to the quality of public services, it is still possible that there might be correlated measurement error associated with the two.

Access to electricity is included as a measure of infrastructure capability, as it embodies the physical necessities required for the delivery of digital services. Countries with low access to electricity are limited in their capacity to implement and utilize digital government services, regardless of their investments in e-governance (Olumekor et al., 2025). The data used in this analysis is the percentage of people who have access to electricity, and it comes from the World Bank World Development Indicators dataset (World Bank, 2024). One concern about the endogeneity of this measure has been noted in the literature (Olumekor et al., 2025; Sarkodie & Adams, 2020), where governance quality is considered to affect infrastructure provision, includ-

Table 3.1: Summary Statistics

Variable	Mean	SD	Min	Max
Government Effectiveness (GE)	-0.0629	0.989	-2.44	2.47
E-Government Development Index (EGDI)	0.4720	0.229	0.00	0.976
Log GDP per capita (lgdppc)	8.4800	1.540	4.70	12.50
Log Population (lpop)	15.5000	2.200	9.18	21.10
Political Stability (PS)	-0.0563	0.991	-3.31	1.76
Access to Electricity (ATE)	0.7960	0.295	0.013	1.00

ing access to electricity. While the introduction of country fixed effects controls for this issue, since this measure is not time-variant, time-variant reverse causality remains possible. Importantly, this measure turns insignificant once country and year fixed effects are introduced into the TWFE model, suggesting that its effect might be captured through other variables included in the analysis.

Table 3.2: Pairwise Correlations

Variable	GE	EGDI	lgdppc	lpop	PS	ATE
Government Effectiveness	1.000					
E-Government Development Index	0.775	1.000				
Log GDP per capita	0.834	0.812	1.000			
Log Population	-0.137	0.101	-0.197	1.000		
Political Stability	0.701	0.465	0.643	-0.534	1.000	
Access to Electricity	0.578	0.692	0.729	-0.115	0.423	1.000

Descriptive Statistics

Descriptive statistics of all variables are presented in Table 3.1. There is significant variation in government effectiveness, which ranges from -2.44 to 2.47. This wide variation indicates substantial differences in the governance quality across countries. As expected, EGDI is also highly variable, varying from 0 to 0.976. As can be seen below in Table 3.2, there are highly significant positive pairwise correlations between government effectiveness, digitalization, income, and infrastructure. However, as was mentioned above, the high correlation coefficients mostly stem from the structural nature of the data set. Overall, government effectiveness is positively correlated with digitalization ($corr = 0.775$), income ($corr = 0.834$), political stability ($corr = 0.701$), and access to electricity ($corr = 0.578$). These patterns indicate that higher governance performance tends to be observed alongside higher levels of economic development, infrastructure, and digital capacity. The E-Government Development Index is also strongly correlated with income ($corr = 0.812$) and access to electricity ($corr = 0.692$), suggesting that digitalization is more advanced in economically and technologically developed environments. By contrast, log population shows weaker and, in some cases, negative correlations with other variables, including government effectiveness ($corr = -0.137$), income ($corr = -0.197$), and

Figure 3.1: Cross-country association between e-government development and government effectiveness (2000–2024)

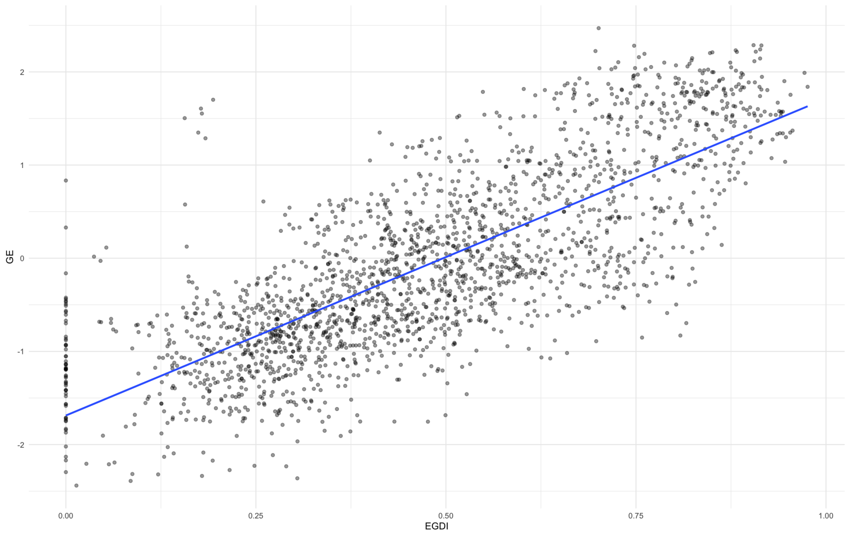


Table 3.3: Summary Statistics by Income Group

	Low income	Lower-middle	Upper-middle	High income
Government Effectiveness				
Mean	−1.190	−0.639	−0.243	0.990
SD	0.521	0.498	0.576	0.694
Min	−2.44	−2.23	−1.96	−0.854
Max	0.388	0.711	1.24	2.47
E-Government Development Index				
Mean	0.205	0.342	0.477	0.676
SD	0.108	0.139	0.160	0.183
Min	0.000	0.000	0.000	0.000
Max	0.549	0.726	0.863	0.976
Log GDP per Capita				
Mean	6.32	7.33	8.50	10.20
SD	0.532	0.688	0.601	0.837
Political Stability				
Mean	−1.120	−0.471	−0.086	0.718
SD	0.964	0.800	0.821	0.577
Access to Electricity				
Mean	0.291	0.643	0.939	0.993
SD	0.237	0.272	0.099	0.027
Countries	22	46	48	56

Notes: Income group classification follows the World Bank definition. Summary statistics computed over all available country-year observations within each group.

political stability ($corr = -0.534$). This indicates that country size is not systematically associated with stronger institutional outcomes and may instead reflect underlying structural differences. Although several correlations are relatively high, pairwise relationships alone do not imply multicollinearity. This issue is assessed more formally using variance inflation factors in the regression analysis.

As can be seen from Figure 3.1, there is a positive cross-country relationship between EGDI and government effectiveness for all country-year observations included in the analysis. Each point stands for one country-year observation. The dashed line denotes the regression results from a pooled OLS model. The positive relationship shown here is in line with the results from Table 3.2 above. Nevertheless, the reason behind this pattern is not causality but rather a cross-sectional structural difference, as developed institutions and wealthiness of a country contribute to high scores on both scales at once.

Table 3.3 presents summary statistics disaggregated by income group, corresponding to the subsamples used in the heterogeneity analysis in Section 4.3. Substantial differences are observed across groups in both the dependent and explanatory variables. Mean government effectiveness ranges from -1.19 in low-income countries to 0.99 in high-income countries, while mean EGDI increases monotonically from 0.205 to 0.676. Political stability and access to electricity follow a similar gradient. These patterns confirm that income groups differ substantially in their baseline institutional and infrastructural conditions, motivating separate estimation for each group.

3.3 Econometric Specification

The empirical analysis follows the panel framework of Wandaogo (2022), published in *Applied Economics*, which employs a fixed-effects approach to estimate the relationship between e-government development and government effectiveness across developing and developed countries. The baseline model is presented in equation 1 below:

$$GE_{it} = \alpha + \beta\, EGDI_{it} + X_{it}\gamma + \mu_i + \lambda_t + \varepsilon_{it} \qquad (1)$$

where:

- GE_{it} denotes the Government Effectiveness indicator from the Worldwide Governance Indicators in country i at time t;
- $EGDI_{it}$ is the primary independent variable, capturing the level of e-government development within the public sector in country i at time t;
- X_{it} is a vector of time-varying control variables, including log GDP per capita, log population, political stability, and access to electricity, each described in detail in Section 3.2;
- μ_i denotes country fixed effects, absorbing unique historical, cultural, or geographical factors that remain constant over the study period but may influence both e-government

development and governance outcomes;

- λ_t denotes time fixed effects, capturing global shocks and common trends affecting all countries simultaneously;
- ε_{it} is the idiosyncratic error term.

The estimation proceeds sequentially across five specifications. The analysis begins with pooled Ordinary Least Squares (OLS) as a benchmark. However, OLS is likely to be biased if the explanatory variables $EGDI_{it}$ and X_{it} are correlated with unobserved country-specific effects μ_i. For example, countries with stronger bureaucratic traditions may exhibit both higher government effectiveness and earlier adoption of digital technologies. If these time-invariant institutional characteristics are omitted, OLS may incorrectly attribute their influence to e-government development, resulting in upward-biased estimates.

A Random Effects (RE) model could improve efficiency, but it relies on the assumption that unobserved country-specific effects are uncorrelated with the regressors, which is unlikely to hold in a macro-institutional context (Angrist & Pischke, 2009; Wooldridge, 2020). To formally assess this assumption, a Hausman specification test is conducted and reported in Section 4.1. Based on this test, the Fixed Effects (FE) estimator is adopted as the primary approach.

The preferred specification is the Two-Way Fixed Effects (TWFE) estimator, which controls for both time-invariant country characteristics and common global shocks (Cunningham, 2021). The relevance of including year fixed effects is assessed through a joint F-test, reported in Section 4.1. Together, these controls allow for a more credible estimation of the within-country association between e-government development and government effectiveness.

To ensure valid inference, standard errors are clustered at the country level throughout, accounting for serial correlation within countries over time (Wooldridge, 2020). Without clustering, standard errors are likely to be underestimated, leading to overstated statistical significance. While alternative approaches such as bootstrapping exist, country-level clustering remains the standard choice for macro-level panel data (Wandaogo, 2022).

3.4 Endogeneity and Limitations

Despite the use of a panel framework and fixed effects, endogeneity remains a central concern in estimating the relationship between e-government development and government effectiveness. Digitalization is not randomly assigned, but reflects policy choices made within existing institutional contexts (Cunningham, 2021). This section outlines the main identification challenges, describes how each is addressed in the empirical strategy, and acknowledges the remaining limitations of those approaches.

Reverse causality. A bidirectional relationship may exist between e-government development and governance outcomes. While digitalization may improve governance, more effective governments may simultaneously be better positioned to implement digital reforms, implying that part of the observed relationship may run from governance to digitalization rather than the reverse. To address this concern, the analysis incorporates lagged values of EGDI in the dynamic specifications presented in Section 3.4.1, ensuring that changes in e-government development temporally precede observed changes in government effectiveness (Wandaogo, 2022). In addition, a reverse causality test is conducted and reported in Section 4.2, which estimates the effect of government effectiveness on subsequent EGDI values. While these steps establish temporal ordering, they do not fully resolve simultaneity in the absence of a valid instrumental variable. The estimated coefficients should therefore be interpreted as conditional associations rather than causal effects.

Omitted variable bias. Although country fixed effects control for time-invariant unobserved characteristics — such as historical institutional legacies, geography, and culture — they do not account for time-varying confounders (Cunningham, 2021). Factors such as political reforms, infrastructure expansion, or shifts in administrative capacity may simultaneously influence both e-government investment and governance outcomes. The inclusion of time fixed effects partially addresses this by absorbing common global shocks affecting all countries in a given year. The control variables — log GDP per capita, political stability, log population, and access to electricity — further account for observable time-varying factors. However, country-specific time-varying confounders that are unobserved and not captured by the controls remain a concern that cannot be fully resolved within the present framework. This is an acknowledged limitation of the study.

Policy endogeneity. Digital reforms may be adopted strategically in response to existing institutional conditions rather than as exogenous interventions (Cunningham, 2021). Countries experiencing governance deficits may invest more heavily in e-government as a remedial strategy, while countries with already strong institutions may do so to consolidate gains. The two-way fixed effects framework partially addresses this by removing time-invariant country tendencies toward digital adoption, and the lag structure further helps by establishing temporal precedence. However, policy endogeneity driven by time-varying strategic behaviour cannot be fully excluded. This study does not employ instrumental variables or Generalized Method of Moments (GMM) techniques. In a macro-institutional context, identifying valid instruments is both empirically and conceptually challenging, and poorly chosen instruments may introduce additional bias (Angrist & Pischke, 2009). This represents a limitation that future research could address through natural experiments or policy discontinuities.

Measurement error. Both government effectiveness and e-government development are captured using composite indices that rely partly on perception-based and qualitative inputs. These measures may not be fully comparable across countries, particularly in developing contexts, and may introduce classical measurement error (Olumekor et al., 2025). In panel settings with fixed effects, measurement error in the dependent variable does not bias coefficient estimates but increases standard errors. Measurement error in the independent variable, however, may produce attenuation bias, leading to downward-biased estimates of the EGDI coefficient.

This implies that the true relationship between e-government development and governance may be larger in magnitude than what is reported in this study. This limitation cannot be fully resolved without alternative measures and should be considered when interpreting the magnitude of results.

Overall assessment. Taken together, the two-way fixed effects framework addresses time-invariant confounding, the lagged specifications establish temporal ordering, the reverse causality test assesses bidirectionality, and the control variables account for observable time-varying factors. However, the most significant unresolved concern is the absence of a credible instrumental variable strategy, which means that time-varying endogeneity cannot be fully excluded. As a result, the estimated coefficients are interpreted throughout as robust conditional associations rather than causal effects. This is consistent with the approach taken in comparable studies in this literature (Labhard & Lehtimäki, 2022; Wandaogo, 2022).

3.4.1 Dynamic Specification and Lag Structure

The effect of e-government development on government effectiveness is unlikely to be immediate. Instead, it unfolds gradually as digital systems are integrated into administrative processes and adopted by both public officials and citizens. As Zou et al. (2023) argued, the benefits of e-government emerge only as digital technologies become embedded within institutional structures. Similarly, Diakite and Wandaogo (2024) emphasize that a diffusion period is required before measurable improvements in governance can be observed. This idea is reinforced by Yang et al. (2024), who show that the effects of digital transformation strengthen over time as adoption deepens.

To account for this delayed response, the model incorporates lagged values of the E-Government Development Index (EGDI) using a distributed lag specification:

$$GE_{it} = \beta_1 EGDI_{it} + \beta_2 EGDI_{i,t-k} + X_{it}\gamma + \mu_i + \lambda_t + \varepsilon_{it} \tag{2}$$

In the empirical analysis, lags of two and four periods are included. This choice reflects the annual structure of the data and the time required for digital reforms to be implemented, adopted, and translated into observable governance outcomes. As shown by Wandaogo (2022), introducing lagged digitalization also helps establish temporal ordering by ensuring that changes in e-government capacity precede observed improvements in effectiveness.

In addition to delayed policy effects, the model accounts for institutional persistence through a dynamic specification that includes a lagged dependent variable:

$$GE_{it} = \rho GE_{i,t-1} + \beta EGDI_{it} + X_{it}\gamma + \mu_i + \lambda_t + \varepsilon_{it} \tag{3}$$

This approach reflects the idea that governance evolves gradually over time. As Acemoglu et al. (2008) demonstrated, institutional outcomes are highly persistent and shaped by past trajectories. Consistent with this, Wandaogo (2022) find that government effectiveness exhibits strong autoregressive behaviour, with current performance closely linked to previous levels.

It is important to distinguish between these two types of lags. Lagged values of EGDI capture delayed policy effects, reflecting the time required for digital reforms to influence governance outcomes. In contrast, the lagged dependent variable captures institutional persistence, representing the structural inertia of governance systems.

Despite these advantages, the dynamic specification introduces additional challenges. Including a lagged dependent variable in a fixed effects framework may lead to Nickell bias, arising from the correlation between the transformed lagged dependent variable and the error term (Nickell, 1981). Given the moderate time dimension of the panel ($T \approx 10$–11), this bias is expected to be non-negligible but not dominant. Accordingly, the dynamic estimates should be interpreted as descriptive of temporal dynamics and persistence patterns rather than as precise causal effects.

Chapter 4. EMPIRICAL RESULTS

This chapter presents the main empirical findings of the study. The dataset includes panel observations across countries and years, combining measures of e-government development (EGDI), government effectiveness (GE), and a set of control variables, including log GDP per capita, log population, political stability, and access to electricity. The panel is unbalanced, as the EGDI was published biennially until 2018, meaning data points for intervening years are unavailable for a large share of the sample period. This feature becomes particularly relevant when comparing contemporaneous and lagged specifications in Section 4.2.

4.1 Baseline Results

Table 4.1 shows the estimated effect of e-government development on government effectiveness in five alternative panel data models, according to the sequential estimation approach explained in Section 3.3.

Column (1) gives the results of the pooled OLS regression model with EGDI as the sole independent variable. The estimated coefficient has a positive value and is statistically significant at the one percent significance level. Nonetheless, this regression model excludes important factors that affect the structure of governance systems and suffers from the omitted variable problem since nations with better institutional structures have high scores for governance and digital governance at the same time.

The regression model in column (2) includes some control variables, such as log GDP per capita, log population, political stability, and access to electricity. The estimated coefficient of EGDI is positive and statistically significant; nevertheless, it decreases sharply from 3.401 to 1.269.

The random effects (RE) estimator is presented in column (3). Although the coefficient for EGDI continues to have a positive sign, the appropriateness of applying the RE model hinges on the assumption that unobservable country-specific effects do not correlate with any regressor. However, such an assumption seems unrealistic in a macro-institutional setting. To formally test this issue, the Hausman specification test is used to compare the two estimators, RE and FE. The Hausman test decisively rejects the null hypothesis of consistently estimated random effects ($\chi^2 = 885.65$, $df = 5$, $p < 0.001$).

In column (4), the results of the country fixed effects (FE) model are reported. In this case, by accounting for time-invariant country-specific variables such as geographic factors, history,

Table 4.1: Effect of e-government development on government effectiveness

	(1)	(2)	(3)	(4)	(5)
Constant	-1.688^{***}	-3.587^{***}	-1.696^{***}		
	(0.033)	(0.297)	(0.327)		
EGDI	3.401^{***}	1.269^{***}	0.161	0.157	0.551^{***}
	(0.064)	(0.220)	(0.117)	(0.125)	(0.133)
Log GDP per Capita		0.285^{***}	0.207^{***}	0.111^{***}	0.256^{***}
		(0.039)	(0.024)	(0.025)	(0.038)
Log Population		0.051^{***}	-0.006	-0.217^{+}	0.051
		(0.013)	(0.018)	(0.131)	(0.136)
Political Stability		0.376^{***}	0.253^{***}	0.176^{***}	0.147^{***}
		(0.036)	(0.027)	(0.027)	(0.027)
Access to Electricity		-0.320^{**}	-0.103	-0.141	-0.068
		(0.114)	(0.109)	(0.151)	(0.133)
Estimator	OLS	OLS	RE	FE	TWFE
Num. Obs.	2074	2046	2046	2046	2046
R^2	0.607	0.793	0.309	0.120	0.175
Adj. R^2	0.606	0.792	0.307	0.027	0.083

Notes: Standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, $^{+}p < 0.1$. Columns (1)–(2): pooled OLS. Column (3): random effects. Column (4): country fixed effects. Column (5): two-way fixed effects (country and year).

and culture, the estimator isolates the effect of interest by exploiting within-country variation over time. In this regression, the EGDI coefficient falls to 0.157 and becomes statistically insignificant. This suggests that after controlling for structural differences across countries, the within-country relationship cannot be detected. This finding is also in line with the interpretation that a large portion of the raw correlation in the pooled estimation is due to cross-country differences rather than within-country dynamics.

Testing the significance of the commonly occurring time shocks is done through a joint $F-$test of year fixed effects. It is found that the null hypothesis of all year effects being zero is rejected ($F = 12.572$, $p < 0.001$). Hence, it can be concluded that there exists empirical relevance of shocks that vary across time. Thus, we extend the FE regression into TWFE, as shown in column (5), where both time-invariant and global shocks are controlled for.

The coefficient of EGDI under the TWFE specification becomes 0.551 and statistically significant at the one percent significance level. This implies that there is a positive effect of e-government development on government effectiveness within each country. Given that EGDI is bounded to lie between zero and one, an increase in the EGDI variable by 0.1 leads to an increase in government effectiveness by 0.055 units. Note that this amount is small relative to the overall standard deviation of 0.989 of the GE variable.

Comparing columns (4) and (5) yields some interesting results. While in column (4), the EGDI parameter is not distinguishable from zero, it means that the relationship within the countries could not be found when time-specific variables were not controlled for. The introduction of year fixed effects in column (5) allows absorbing the impact of global shocks on all countries, resulting in a more accurate estimation with a larger and significant EGDI parameter. Thus, the TWFE model is proven to be the correct baseline for our analysis.

In terms of controls, GDP per capita and political stability retain their positive and statistically significant values, supporting the fact that economic development and stability in politics are known determinants of good governance. However, population and electricity become insignificant after the inclusion of both country and year fixed effects, indicating that their explanatory power could be attributed to other country-specific factors.

4.2 Dynamic Effect of E-Government Development

For assessing the dynamics of e-government development, the baseline model is updated by adding lags for EGDI, as discussed in section 3.4.1 (equation 2).

The first column in Table 4.2 reproduces the TWFE result from the baseline regression in equation 1. The estimated coefficient on e-government development is found to be positive and significantly different from zero at the 1% significance level ($\beta = 0.551$).

Column (2) shows the outcomes of the two-period lag model (equation 2). The estimate of the contemporaneous EGDI drops sharply from 0.551 to 0.307, becoming barely significant, whereas the two-period lagged term proves positive and significantly different from zero at the 5% level ($\beta = 0.456$). With the inclusion of the contemporaneous variable, its estimated coefficient includes both the instantaneous and delayed effects that are positively correlated with the present value. Adding the lagged term, the two are distinguished from each other. Thus, the decline of the former along with the rise of the latter suggests a distributed-lag nature of the impact of EGDI on governance. It means that the change in EGDI in the period t has a larger influence on the change in governance in the period $t+2$ than in period t.

A Wald test of the hypothesis $H_0 : \beta_1 = \beta_2 = 0$ rejects the null strongly ($\chi^2 = 17.15$, $p < 0.001$), which implies the statistical significance of e-government development variables even if the contemporaneous variable is barely significant on its own.

Table 4.2: Dynamic effect of e-government development on government effectiveness: distributed lag specifications

	(1)	(2)	(3)
EGDI (t)	0.551^{***}	0.307^{*}	0.234
	(0.133)	(0.145)	(0.192)
EGDI $(t-2)$		0.456^{**}	0.287^{*}
		(0.164)	(0.122)
EGDI $(t-4)$			0.661^{**}
			(0.225)
Log GDP per capita	0.256^{***}	0.271^{***}	0.233^{***}
	(0.038)	(0.043)	(0.063)
Log Population	0.051	0.149	0.267
	(0.136)	(0.157)	(0.302)
Political Stability	0.147^{***}	0.157^{***}	0.172^{***}
	(0.027)	(0.031)	(0.039)
Access to Electricity	−0.068	0.047	0.323
	(0.133)	(0.144)	(0.234)
Observations	2046	1501	1129
R^2	0.175	0.169	0.131
Adj. R^2	0.083	0.039	−0.057

Notes: Two-way fixed effects (country and year) in all columns. Robust standard errors clustered at the country level in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Column (3) adds the four-period lag into the model. While the coefficient on $EGDI_{t-4}$ is positive and statistically significant ($\beta = 0.661$), the contemporaneous variable turns out to be statistically insignificant. Nonetheless, the addition of the four-period lag leads to a decrease in the number of observations from 1,501 to 1,129 and generates an adjusted R^2 that is negative, implying a poorer model fit. The decrease in the number of observations is attributed to the requirement that four successive observations for each country must be available in order to create four-period lags, which is quite challenging due to the fact that EGDI is published biannually. In light of this, the estimates reported in column (3) are not robust.

4.2.1 Institutional Persistence

In order to address the issue of strong persistence observed in the relationship between governance and e-government development documented above, an extension of the model incorporating a lagged dependent variable is introduced (see equation 3).

The regression output for the model is presented in column (1) of Table 4.3. The estimated persistence parameter is quite high and highly statistically significant ($\rho \approx 0.748$, $p < 0.01$), suggesting that about 75 percent of the variation in government effectiveness in the period t can be attributed to its own value in the previous period $t-1$. Once the impact of persistence is taken into account, the estimated coefficient for EGDI declines significantly from 0.551 in the baseline model to 0.133 and becomes statistically insignificant. Such a decline can be partially attributed to the fact that, at least partly, the effect observed in the baseline was due to persistent countries with effective governance in $t-1$ also had a relatively high level of EGDI in t.

In column (2), contemporaneous EGDI is replaced with a two-period lag. While the coefficient remains positive and statistically significant ($\beta \approx 0.156$, $p < 0.1$), the value of the persistence parameter does not change much and stays high ($\rho \approx 0.712$).

Table 4.3: Dynamic specifications with lagged dependent variable

	(1)	(2)
EGDI (t)	0.133^{*}	
	(0.056)	
EGDI $(t-2)$		0.156^{*}
		(0.062)
Government Effectiveness $(t-1)$	0.748^{***}	0.712^{***}
	(0.024)	(0.029)
Log GDP per capita	0.082^{***}	0.080^{***}
	(0.015)	(0.018)
Log Population	0.077^{+}	0.066
	(0.046)	(0.061)
Political Stability	0.065^{***}	0.065^{***}
	(0.013)	(0.016)
Access to Electricity	0.081	0.052
	(0.062)	(0.075)
Num. Obs.	2013	1843
R^2	0.656	0.605
Adj. R^2	0.618	0.557

Notes: Two-way fixed effects (country and year). Robust standard errors clustered at the country level in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$, $^{+}p < 0.1$.

Overall, the findings presented in Tables 4.2 and 4.3 highlight two important findings. Firstly, the relationship between the level of e-government development and governance is time-distributed, rather than contemporaneous, and is more pronounced in terms of effects at two- and four-year intervals. Secondly, governance measures exhibit considerable inertia, and the effect of e-government development occurs in such an inertial setting rather than in the face of it. While these results must be treated with caution due to the possible endogeneity and methodological issues related to dynamic panel regression models, there is a particular problem of estimating a model with a lagged dependent variable within a fixed effects framework due to Nickell bias. Specifically, the transformed lagged dependent variable becomes correlated with the error term, and given the small time dimension of the panel data ($T \approx 10$–11), the resulting bias will not be negligible but will be non-negligible and non-dominant.

4.3 Heterogeneity

These findings need to be considered exploratory due to relatively small sample sizes in certain income groupings, as well as the lack of formal coefficient equality testing procedures that could confirm significant differences. Rather than attempting to determine specific causal relationships in various subgroup settings, the objective is to find out if the initial correlation between e-government development and government effectiveness changes consistently across different settings.

The sample is initially split between developed and developing nations according to the World Bank classification. As can be seen from Table 3.3, there is a large difference in the level of governance and e-government development between these two categories, where high-income countries have an average GE score of 0.990, whereas low-income countries score at -1.190, and 0.676 EGDI in contrast to 0.205.

Table 4.4: Heterogeneity by development status

	Developed	Developing
EGDI	0.447^{*}	0.495^{***}
	(0.258)	(0.184)
Political Stability	0.116^{**}	0.148^{***}
	(0.046)	(0.031)
Log GDP per capita	0.269^{***}	0.240^{***}
	(0.088)	(0.049)
Log Population	0.191	-0.296
	(0.180)	(0.195)
Access to Electricity	-0.954	-0.041
	(1.058)	(0.165)
Observations	587	1128
R^2	0.11	0.23

Notes: Two-way fixed effects estimates. Robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

From Table 4.4, it can be observed that the positive correlation of digitalization and effectiveness of government is evident in both subgroups. The coefficient of regression analysis for developed countries and developing countries is, respectively, 0.447 ($p < 0.1$) and 0.495 ($p < 0.01$). It should be noted that there are similarities between the two coefficients, meaning that the relationship between development of e-government and governance is similar for both developed and developing countries. In this regard, a hypothesis test of equality of coefficients reveals that the coefficient associated with the interaction of EGDI with a dummy variable for developed countries is statistically insignificant ($p = 0.556$). For both sub-samples, political stability and GDP per capita are positive and statistically significant. However, the coefficient of access to electricity for the developed country is large and negative but has a high standard error of 1.058, indicating a zero precision.

In order to further explore heterogeneity, the sample is classified into four income categories: low-income, lower-middle-income, upper-middle-income, and high-income countries, according to the classification scheme adopted by the World Bank in the summary statistics presented in Table 3.3. As shown in Table 4.5, the estimate of the coefficient on e-government

Table 4.5: Heterogeneity by income groups

	Low income	Lower middle	Upper middle	High income
EGDI	1.404***	0.473***	0.278	0.447***
	(0.394)	(0.154)	(0.192)	(0.154)
Political Stability	0.157***	0.125***	0.167***	0.116***
	(0.030)	(0.027)	(0.030)	(0.042)
Log GDP per capita	0.241***	0.248***	0.263***	0.269***
	(0.085)	(0.044)	(0.053)	(0.049)
Log Population	0.110	0.703***	−0.708***	0.191**
	(0.347)	(0.178)	(0.166)	(0.080)
Access to Electricity	0.314	0.127	0.112	−0.954
	(0.278)	(0.114)	(0.309)	(1.030)
Observations	202	451	475	587
Countries	22	46	48	56
R^2	0.34	0.21	0.23	0.11

Notes: Two-way fixed effects estimates. Robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

development differs by income categories. It attains its highest value among low-income countries (1.404, $p < 0.01$) and lower-middle-income countries (0.473, $p < 0.01$) followed by high-income countries (0.447, $p < 0.01$). On the other hand, the coefficient on upper-middle-income countries is relatively small (0.278) and statistically insignificant.

It should be noted that the findings in the case of the subsample of poor countries should be treated with utmost care since this subsample only includes data for 22 countries and 202 cases. In light of the small sample, the estimate of 1.404 will depend on the unique nature of each country and thus might not represent the poor countries as a whole.

In a broader context, however, there is no monotonicity in the income groups' effect on the coefficients. In combination with the fact that the upper-middle-income coefficient turned out to be insignificant while the values for both lower-middle-income (0.473) and high-income (0.447) countries were fairly similar, it can be concluded that there is more than just a simple correlation between the income level and the e-government's development-governance link. In order to make a statistically sound decision about whether there is heterogeneity within the sample, a regression with interactions is estimated, taking low-income countries as the base. The individual interaction effects are insignificant, and so is their combined value (the joint hypothesis is rejected only at the 0.82 confidence level, $\chi^2 = 0.938$, $df = 3$, $p = 0.816$). The pairwise comparisons do not show any significant differences either, for both high-income and lower-middle-income countries (p = 0.979) and for upper-middle-income and lower-middle-income countries (p = 0.549). As can be seen from these findings, the differences between the point estimates are likely to be driven by low statistical power associated with small subsamples instead of a lack of heterogeneity. Hence, we must consider the results for different subgroups as indicative of certain trends instead of being precise estimates of differential impacts. This also follows from the statistics provided in Table 3.3, according to which both the mean level of governance and the EGDI increase monotonically in different income groups. However, substantial variation persists in each group as well, indicating that the non-monotonic nature of the estimates might have been caused by underlying heterogeneity in terms of institutional quality and ability to implement reforms.

While the positive correlation between political stability and GDP per capita continues to hold in all subgroups, the remaining control variables exhibit more unstable trends. All in all, we can conclude that heterogeneity analysis suggests that there are multiple country groups where a positive impact of the former on the latter exists, yet the effect is not universal across various income levels.

Chapter 5. DISCUSSION

This section discusses the interpretation of empirical results obtained in this research based on research questions raised at the very beginning of the paper and the theoretical background established in the literature review.

The main result of this analysis is a positive and significant relationship between the growth of e-government and government effectiveness. According to the optimal model specification with two-way fixed effects, the effect of EGDI on GE is equal to 0.551. Hence, it implies that for each increase in the EGDI by 0.1 points, the level of government effectiveness increases on average by 0.055 points. This relation is stable under various model specifications, but at the same time, its significance decreases from 3.401 in the OLS regression model to 0.551 when controlling for country and year fixed effects.

The significant reduction in the magnitude of the coefficient is what makes up the core innovation in terms of methodology in this paper. In essence, the findings suggest that a considerable amount of the cross-country correlation reported in earlier research was due to pre-existing structural features. They include institutional histories, economic development, and infrastructure, and not necessarily due to the dynamics of digitization itself. The reason why countries exhibit high scores on both governance and e-government indices is due to the fact that they were already at an advanced level of development before digitization occurred. Using the TWFE approach to focus on within-country dynamics reduces any potential overestimation of the effect of digital technologies, which might have been reported in earlier research.

Dynamic specifications also bring more complexity to this image. While adding a two-period lagged variable of EGDI in addition to the current-period one leads to decreasing the current-period coefficient down to 0.307. In contrast, the lagged EDGI is positive and statistically significant at the five percent significance level ($\beta \approx 0.456$). It can be interpreted within the framework of the practice of reforms in the government sector when a certain time lag is needed to implement a digital system, integrate it into the bureaucratic system, and make officials and citizens use it. The four-lag period yields a coefficient estimate of 0.661, but this value should be interpreted with caution because of the smaller sample size and negative adjusted R-squared due to the requirement of four consecutive observations by each country in the case of the EGDI variable. Overall, it can be noted that the beneficial impact of digitization on governance quality is observed approximately two to four years later.

The high institutional persistence coefficient of about 0.75clearly supports the amplification over transformation interpretation. In the presence of a lagged dependent variable, government effectiveness in the period $t-1$ accounts for about 75 percent of the governance performance currently, and the contemporaneous coefficient on EGDI declines to 0.133, which becomes statistically insignificant. This result suggests that the outcomes of governance are very inertial, and its performance in the current period is strongly determined by its history. In this situation, digitalization does not alter the course of the state or reform it but serves as an amplifier that operates under the existing institutional capacity. If the institutional base is weak, then there will be little that digitalization can do to improve the governance performance; if the institutional base is strong, then digitalization can only further cement this advantage. Given the level of inertia, it is clear that the scope for short-run policy intervention for rapid improvement is more limited than digitalization proponents think.

While the heterogeneity test shows a non-monotonic trend between the income groups, which must be seen as exploratory in nature, it would be wise to exercise caution when interpreting the findings. While the highest estimate ($1.404; p < 0.01$) comes from the low-income country sample, it is important to note that the latter comprises just 22 nations and 202 data points. For the comparison between developed and developing countries, the estimates are close in magnitude (0.447 and 0.495) while the hypothesis test results show that income group differences cannot be distinguished from zero. This lack of a gradient between income classes indicates that current income categorizations may be inadequate in accounting for the institutional setting that influences the relationship between digitalization and better governance. Namely, the extent of existing administrative capacity, the level of reform execution, and the political climate regarding digitalization.

However, several shortcomings, as well as issues with endogeneity, persist. First and foremost, there is no instrument variable approach, which means that the issue of time-variant reverse causality remains unsolved. As can be seen from the reverse causality test, the coefficients of the impact of government effectiveness on future EGDI levels amount to about 0.041 to 0.048, meaning that it is only one-tenth of the size of the effect that runs in the other direction. This conclusion suggests that reverse causation cannot be used to account for the link between the two variables under consideration, as the second one is not caused by the greater ability of the first one to operate advanced technologies. However, considering that more effective states can react to specific factors in terms of implementing e-government in the best manner possible, this relationship should be viewed as conditional.

The results are remarkably consistent with the study carried out by the latter, Wandaogo (2022) since the latter's panel model and variable construction were the starting point for developing the econometric model used in this study. While the basic positive relationship was confirmed using a much bigger and newer dataset, the new insights into the lag structure and persistence further refine the results of Wandaogo. On the other hand, the results presented support the amplification theory proposed by Labhard and Lehtimäki (2022). According to these authors, digitization simply amplifies the existing institutional strengths without changing them at all, which is also what was found in this study. Furthermore, contrary to the theory of radical transformation, the findings suggest that it is the persistence value of about 0.75 that underlies such an approach to interpreting the effect of digitalization on institutional development. Indeed, digital tools' effectiveness depends greatly on institutional quality, and the development of governance structures is determined more by its past history than anything else.

Chapter 6. CONCLUSIONS

In this research, the question was posed regarding whether the domestic growth in digitalization will lead to further gains in the efficiency of governance, analyzing a worldwide dataset of 172 countries from 2000 to 2024. By employing a longitudinal methodology supported by the two-way fixed-effect model, the objective was to differentiate between merely possessing the latest technologies in a country and their actual influence on the effectiveness of administration regarding institutional inertia. Instead of comparing countries across borders, as is typically done when considering the impact of reforms and developmental processes, the focus was put on within-country variations.

The findings reveal a positive and statistically significant relation between the development of e-government levels and government effectiveness. Nevertheless, this relationship seems to be much less pronounced than the one implied by the existing literature. First of all, after taking into account country fixed effects as well as time-invariant global trends, the EGDI coefficient drops sharply from 3.401 the OLS pooled regression to 0.551. This implies that there is a considerable number of other structural factors that lead to a higher government effectiveness, but the contribution of e-government is relatively small, which explains the weak results obtained in the panel regression analysis. Moreover, the effect of digitalization is not immediate since it takes several years before reforms and changes brought about by the implementation of digital innovations can become apparent. In terms of income groups, the effect is positive in all three categories, with high-income countries showing a weak link and low-income countries providing the strongest evidence in favor of the research hypothesis. However, these findings need to be treated carefully because the low-income sample includes only 22 countries.

The contribution of this study is two-fold. First, from a methodological point of view, the study contributes to the literature by adopting the TWFE approach using a globally exhaustive panel. This allows real country-specific effects to be analyzed and leaves out biases of historical and cultural differences. From a pragmatic point of view the study supports the amplification hypothesis rather than the transformation hypothesis. This implies that the institutional inertia anchor can be estimated at about 0.75. The number clearly shows that institutions are well established on the basis of prior performance, and digitalization is only a supporting tool in this environment.

These results have generated a number of policy prescriptions. First, don't chase digitalization just for the sake of it. It depends on how well the existing institutions are developed.

Therefore, investments in digitalization should be placed in the general context of investments in the improvement of administrative capacities of countries. Second, the digitalization implementation process must be planned with a long-term perspective, as the dividends from such efforts will take time to realize. For example, it takes years before the real benefits are reaped from the adoption of the technology. Thus, there is no need to evaluate its short-term success. Third, the policymakers should focus on digitizing the internal back-office operations of the bureaucracies instead of focusing on making the front end visible. Finally, the effect estimates for this category are relatively large in magnitude, so digital investments in low-income countries may yield relatively large returns. However, this recommendation should be treated with caution as the number of countries used in this study is very small.

This study offers a more cautious and methodologically clear-eyed assessment of the digitalization–governance relationship, but there remain a number of limitations. No valid instrumenting strategy is available so that endogeneity cannot be ruled out completely. Therefore, the results should be interpreted as strong conditional associations, not causal effects. Internal administrative processes are not directly observed as perception-based governance indicators and a front-end-focused digitalization measure is used. These mechanisms are likely to be the most important determinant of the quality of governance. Future research should aim to fill these gaps with natural experiments, policy discontinuities, or administrative data that captures back-end institutional transformation. Individual technologies, such as artificial intelligence, blockchain technology or data infrastructure, impact individual activities, which are performed by governments. How is a question for further studies. This may enable the literature to move beyond composite indexes to a more nuanced exploration of what digital technologies matter and when.

Overall, the findings suggest that digitalization alone is not enough to transform institutions without broader improvements in governance capacity.

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