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DOES GOVERNMENT DIGITIZATION CONTRIBUTE TO ECONOMIC GROWTH? EMPIRICAL EVIDENCE FROM 109 COUNTRIES

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Abstract. In the digital age, governments worldwide are increasingly turning to digitization to enhance efficiency and foster economic growth. This study investigates the impact of government digitization on economic growth, addressing the pressing issue of how digital transformations within the public sector can drive economic growth. First, we empirically estimate panel data from 2002 to 2021 across 109 countries using multiple statistical methods, consistently supporting that government digitization can significantly promote economic growth. Subsequently, mechanism tests are conducted using two fixed effect models containing interaction terms, revealing that government digitization can foster economic growth by curbing corruption and reducing the time businesses need to access public services. Furthermore, heterogeneity analysis confirms the moderating effects of telecommunications infrastructure, basic education popularization, natural resource abundance, government efficiency, democracy, and ruling party ideology on the relationship between government digitization and economic growth. Lastly, quantile regression reveals a nuanced pattern, indicating that as a country's economic development level increases, the promoting effect of government digitization on economic growth initially rises before declining. These findings provide new insights for governments worldwide seeking economic growth.

Keywords: government digitization, economic growth, Cobb-Douglas production function, resource curse, government efficiency.

JEL Classification: O33, O43, H11, C23.

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1. Introduction

Global economic growth is encountering serious challenges due to various factors including the COVID-19 pandemic, the conflict between Russia and Ukraine, and the surge in oil prices (Naseer et al., 2023). According to The Global Information Technology Report by Bilbao-Osorio et al. (2013), and European Investment Bank (2022), digitization is a powerful economic accelerant. Indeed, the capacity of digitization to foster economic growth has been extensively validated by academia. To name a few, Myovella et al. (2020), Bon (2021), Ishnazarov et al. (2021), Novikova et al. (2022) and Török (2024) all empirically confirmed the positive role of digitization on economic growth. While the broader impact of digitization on

economic growth is undeniable, it is crucial to recognize the role of government in shaping the digital transformation agenda. As both policymakers and providers of public services, government institutions play a central role in advancing the digitization agenda and unlocking its full potential for economic growth. As such, the process through which governments leverage digital technologies to improve administrative efficiency and provide public services is crucial. Therefore, this study will focus on investigating the role of government digitization[1] on economic growth.

A few studies have examined the effect of government digitization on economic growth (Krishna & Sebastian, 2021; Majeed, 2020; Usmanova, 2021). Specifically, Majeed (2020) empirically estimated 122 countries' panel data from 2003 to 2015 and found that government digitization can significantly improve economic performance. Similarly, using structural equation modeling (SEM) to analyze the 127 countries' data from 2014 to 2019, Krishna and Sebastian (2021) also confirmed the positive role of government digitization in economic prosperity. However, different from the finding obtained by the previous two studies, Usmanova (2021) employed static panel models to estimate data from 193 countries between 2008 and 2018 and concluded that a higher degree of government digitization leads to lower GDP growth rate.

While previous research preliminarily investigated whether government digitization affects economic growth, they have not reached a consensus. More importantly, existing literature has certain limitations, which leave room for further exploration. First, they all solely empirically examined the direct impact of government digitization on economic growth, without examining the underlying mechanisms. Second, the existing literature did not adequately consider the varying baseline conditions of different countries. In other words, they did not explore the link between government digitization and economic growth within the specific context of each country, which could lead to biased conclusions. Finally, the existing studies only conducted empirical tests on this relationship without providing a theoretical framework for this influence, resulting in a lack of theoretical support for their findings.

In order to close the previously indicated gaps, this study implemented the following improvements, which may also represent its marginal contributions. First, this study not only empirically tested the direct effect of government digitization on economic growth but also investigated the underlying mechanisms from the two perspectives of reducing corruption and streamlining access to public services for businesses[2]. The mechanism investigation can provide a deeper understanding of the relationship between government digitization and economic growth. Second, this study investigated the impact of government digitization on economic growth within the specific social infrastructure, natural resources, political, and economic backgrounds. This approach can help us obtain more reliable conclusions and thereby propose more targeted policy implications. Additionally, this paper not only conducted a series of empirical examinations on the relationship between government digitization and economic growth but also presents a theoretical framework for this relationship, which is

[1] Government digitization refers to the utilization of advanced information and communication technology (ICT) by governments to streamline operations and enhance the online delivery of information and services to citizens (Verma & Dawar, 2019).

[2] The two mechanisms are further discussed in Section 2.

derived from the Cobb-Douglas production function. This not only provides a theoretical basis for the impact of government digitization on economic growth, but also enriches the application of Cobb-Douglas production function.

The Section 2 of this paper develops the hypotheses for empirical examination in this study. Subsequently, the Section 3 delineates the theoretical framework, data, and methods employed in the study. Empirical findings and their corresponding discussions are expounded upon in Section 4. Lastly, Section 5 furnishes a succinct summary of the principal findings, elucidates policy implications, and acknowledges extant limitations yet to be addressed.

2. Hypothesis development

Government digitization could promote economic growth from the following two aspects. First, government digitization could promote economic growth by suppressing corruption. Government digitization helps to establish a more transparent governance system, thereby improving government integrity (Khan et al., 2021). When governments become more incorruptible, public resources and manpower are more likely to be used for actual production driving economic development, rather than being wasted on dealing with red tape or rent-seeking (Demetriades & Law, 2006). Second, government digitization could promote economic growth by shortening the time it takes for businesses to access public services. According to Mohamed et al. (2023), government digitization can streamline public service processes through online, automated, and simplified procedures, enabling businesses to access public information and complete relevant procedures such as applications and approvals more quickly. In other words, the enhancement of government digitization can shorten the time it takes for businesses to access public services. This shortened time cycle helps improve the production efficiency of enterprises, as they can invest the saved time and resources into production. At the same time, faster access to public services also contributes to accelerating the expansion of business activities, thereby promoting market activity and economic prosperity. As such, we propose Hypothesis 1 as follows.

H1: *Government digitization could stimulate economic growth.*

H1a: *Government digitization could stimulate economic growth by controlling corruption.*

H1b: *Government digitization could stimulate economic growth by reducing the time businesses need to access public services.*

Although government digitization provides the potential to shorten the time for businesses to access public services, whether this potential can be realized also depends on whether businesses have the conditions or capabilities to access public services through online platforms. The conditions for businesses to access public services through online platforms can be influenced by telecommunications infrastructure. When a country's telecommunications infrastructure is more advanced, businesses could find it more advantageous to access public services through online platforms, as enhanced telecommunications infrastructure typically involves broader internet coverage and higher internet speeds, facilitating businesses' utilization of online platforms for accessing public services. In other words, the improvement of telecommunications infrastructure makes government online services more accessible and

efficient, thereby strengthening the positive effect of government digitization on economic development. As such, we put forward Hypothesis 2. The capabilities for businesses to access public services through online platforms can be influenced by the popularization of basic education. Increasing popularization of basic education can enable more people to acquire digital skills (Saydaliev & Chin, 2023), allowing them to effectively utilize online platforms to access public services. In other words, the improvement in digital skills among the workforce resulting from the widespread dissemination of basic education contributes to expanding business participation in accessing public services through online platforms, thereby strengthening the positive impact of government digitization on economic growth. As such, Hypothesis 3 is proposed.

H2: *Telecommunications infrastructure positively moderates the positive relationship between government digitization and economic growth.*

H3: *Popularization of basic education positively moderates the positive relationship between government digitization and economic growth.*

The abundance of natural resources in a country could also influence the relationship between government digitization and economic growth. Countries rich in natural resources often face the challenge of resource curse, where an overreliance on natural resources can hinder economic development. In this situation, governments' efforts towards digitization could encounter greater resistance, as revenue from natural resources could lead to delays or deviations in investments and reforms for digitization. In other words, in resource-rich countries, stable and substantial revenue from resources might lead governments to overlook their own digitization construction, thereby weakening the potential contribution of government digitization to economic growth. Hence, Hypothesis 4 is proposed.

H4: *The abundance of natural resources negatively moderates the positive impact of government digitization on economic growth.*

Wen et al. (2022) pointed out that the behavior of a country's government can be influenced by its political context, reminding us of the necessity to explore the relationship between government digitization and economic growth within specific political environments. In other words, it is essential to investigate the impact of certain political variables (e.g. government efficiency, democracy, and ruling party ideology) on this relationship. Regarding government efficiency, efficient government institutions typically possess the capability for rapid decision-making and robust execution (Ding et al., 2022), implying that efficient governments are more likely to swiftly advance the development of government digitization and the popularization of government digital systems, thus creating more favorable conditions for economic growth. Based on this, we propose Hypothesis 5. In terms of democracy, compared to democratic countries, governments in authoritarian countries typically possess greater centralization, enabling them to exert stronger control over resource allocation for advancing digitization without interference. Moreover, authoritarian governments are more likely to devise long-term and stable plans in their own digital development as they are less susceptible to changes in political regimes. Conversely, democratic countries may encounter challenges from political maneuvering, resulting in the impeding of digitization initiatives. Consequently, in authoritarian countries, the construction of digital government is more likely to receive consistent and stable resource allocation, thus fostering conditions more conducive

to economic growth. As such, Hypothesis 6 is put forward. The ideology of the ruling party could also influence the relationship between government digitization and economic growth. As per Ding et al. (2022), the ideology of the ruling party can shape the government's priorities across various fields, as the ruling party tends to prioritize sectors in which they can gain votes, especially during re-election campaigns. Specifically, left-wing parties typically favor backing labor-intensive industries, whereas right-wing parties are inclined to prioritize capital-intensive industries (Qiu et al., 2019). As such, government digitization initiatives, as projects requiring significant capital investment, are more likely to receive attention from right-wing parties and thus create more favorable conditions for economic growth. Based on this, we propose Hypothesis 7.

H5: *Government efficiency positively moderates the positive relationship between government digitization and economic growth.*

H6: *Democracy negatively moderates the positive relationship between government digitization and economic growth.*

H7: *Ruling party ideology moderates the positive relationship between government digitization and economic growth, whereby when right-wing parties are ruling, the positive impact tends to be stronger.*

Fifth, as mentioned earlier, government digitization initiatives require significant capital input, which reminds us that government digital transformation could be limited by a country's level of economic development. Consequently, government digitization's impact may vary at different stages of economic growth, making it necessary to explore the diversity of this impact. In low-income regions, the advancement of government digitization could face constraints due to capital shortages. Specifically, these countries could lack the necessary funds to invest in digital infrastructure and digital talent training, thus limiting the potential of government digitization to drive economic growth. As national economic strength grows, the problem of government digitization not effectively driving economic growth resulting from capital shortages could gradually diminish. However, as national income level further increases and is accompanied by further improvement in government digitization, the focus of government digitization improvement could shift more towards optimizing existing digital systems rather than making fundamental changes as seen in middle-income countries. As such, the stimulative effect of government digitization on economic growth could gradually weaken. Based on this, we propose Hypothesis 8.

H8: *With the improvement of national economic level, the positive impact of government digitization on economic growth shows a trend of first rising and then falling.*

3. Theoretical framework, data and methodology

3.1. Theoretical framework: an extended Cobb-Douglas production function considering government digitization

This theoretical framework is derived from Cobb-Douglas production function. It is assumed that the Cobb-Douglas production function as shown in Equation (1) determines output in each country. In this Equation, Y_{it}, K_{it}, and L_{it} respectively represent the real output, physical

capital stock, and raw labor stock of country i at time t. A_{it} represents total factor productivity of country i at time t, which can reflect production efficiency. Marginal diminishing effect believes that the returns on capital and labour are declining. As such, we assume that α and β in Equation (1) is a positive value less than 1. Incorporating government digitization into the Cobb-Douglas production function is assumed to be developed based on Equation (2). In Equation (2), g_i, P_{it}, and θ_i respectively represent the exogenous rate of technological advancement in country i, a vector of government digitization in country i at time t, and a vector of the coefficient associated with government digitization. In this framework, the condition of total factor productivity (i.e. variable A) is influenced not only by exogenous technological advancements, determined by g, but also by government digitization level. As discussed in Section 2, on the one hand, government digitization can curb corruption by improving government transparency. An incorruptible government helps to ensure that labor can be utilized for production, rather than being squandered on addressing red tape or rent-seeking endeavors (Demetriades & Law, 2006), which improves production efficiency. On the other hand, government digitization can improve production efficiency by reducing the time required for enterprises to obtain public services. Reflected in the Equations, the rise of P_{it} will cause the increase of A_{it}, which in turn results in the growth of Y_{it}, that is government digitization can promote economic growth.

$$Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{\beta}; \tag{1}$$

$$A_{it} = A_{i0}e^{g_i t + P_{it}\theta_i}. \tag{2}$$

3.2. Data

To validate the hypotheses proposed in Section 2, this paper will conduct a series of empirical examinations. More specifically, based on data availability, this paper will use panel data from 109 countries[3] from 2002 to 2021 to empirically examine the impact of government digitization on economic growth. Per capita GDP (*GDP*) is the dependent variable in this study. The main variable of interest in this study is government digitization (*GD*). According to Verma and Dawar (2019), government digitization is manifested in the use of sophisticated information and communication technology (ICT) by governments to optimize administrations and improve the online delivery of information and services to citizens. In other words, the extent to which a government can provide online services to residents could be used to measure the digitization level of the government. As such, we use online service index released by the United Nations as the proxy of *GD*, which measures the scope and quality of online services provided by governments (Castro & Lopes, 2022). In addition, referring to Abendin and Duan (2021), some indicators that could affect economic growth, such as gross fixed capital formation (*GFCF*), total labor force (*TLF*), foreign direct investment stock (*FDI*), financial development (*FD*), consumer price index (*CPI*), and research and development expenditure (*RDE*) are incorporated as control variables within the analytical framework. The proxies for these six control variables are the ratio of gross fixed capital formation to GDP, the number of people aged 15 and above engaged in supplying labor for the production of goods and services, the ratio of foreign direct investment inflows to GDP, financial development index,

[3] The country list is provided in List A1 of the Appendix.

consumer price index (2010 = 100), and the ratio of R&D expenditure to GDP, respectively. The data for the above indicators can be obtained from Division for Public Institutions and Digital Government of the United Nations, the World Development Indicator (WDI) database, and the financial development index database of International Monetary Fund. It should be noted that, due to the fact that the United Nations does not release the online service index data annually, this study actually covers the years 2002, 2003, 2004, 2007, 2009, 2011, 2013, 2015, 2017, 2019, and 2021[4].

Table 1 presents the descriptive statistics for all the variables mentioned above. It can be observed that the values of all variables are greater than or equal to 0. Of particular note are the large standard deviations observed for *GDP* and *TLF*, suggesting significant heterogeneity in wealth and labor force across the 109 sample countries. Conversely, the standard deviations for the remaining variables are relatively modest, indicating less variability in the data for these variables.

Table 1. Descriptive analysis results of full sample

Category	Variable Name	Measurement	Mean	Standard Deviation	Min	Max
Dependent variable	GDP	US Dollar, 2015	18,676.75	20,568.81	296.85	1.12e+05
Independent variable	GD	Index	0.59	0.22	0.00	1.00
Control variables	GFCF	Ratio	0.21	0.06	0.06	0.58
	TLF	People	3.08e+07	1.00e+08	1.59e+05	7.81e+08
	FDI	Ratio	0.06	0.24	0.00	4.49
	FD	Index	0.43	0.26	0.03	0.98
	CPI	Index	103.93	42.31	32.59	550.93
	RDE	Ratio	0.01	0.01	0.00	0.05

Note: *GDP* – Per capita GDP; *GD* – Government digitization; *GFCF* – Gross fixed capital formation; *TLF* – Total labor force; *FDI* – Foreign direct investment stock; *FD* – Financial development; *CPI* – Consumer price index; *RDE* – Research and development expenditure.

3.3. Methodology

3.3.1. Benchmark estimation and robustness checks

This study will make a series of empirical estimates to test Hypothesis 1. First, this study constructs a fixed effect model, as shown in Equation (3), as the benchmark estimation model. In this Equation, Z represents the control variables utilized in this study, while μ_i and ν_t denote the fixed effects for countries and years, respectively. The coefficients for estimation are denoted by α_0, α_1 and β, with ε_{it} representing the error term. It is crucial to mention that the variables *GDP*, *TLF*, and *CPI* will be logarithmically transformed to mitigate issues related to heteroscedasticity.

$$Ln(GDP_{it}) = \alpha_0 + \alpha_1 GD_{it} + \beta Z_{it} + \mu_i + \nu_t + \varepsilon_{it}\,. \tag{3}$$

[4] The United Nations actually released the data of the previous year. For example, the United Nations released the online service index data of 2021 in 2022.

To verify the reliability of the benchmark regression, this study will conduct several robustness checks. The first of these checks involves a placebo test, motivated by the concern raised by Ding et al. (2024) that the observed influence of government digitization on economic growth in the benchmark regression could be a placebo due to the constraints in the study's design. Referring to Cornaggia and Li's (2019) suggested approach, the placebo test entails the initial extraction of all *GD* data, which are then randomly assigned to each sample. Subsequently, Equation (3) is re-estimated. If the influence of government digitization on economic growth demonstrated in the benchmark model is indeed a placebo, *GD* in the placebo assessment would produce a coefficient that is significant and holds the same sign as that of the benchmark regression.

The second robustness check involves altering the dependent variable. GDP growth rate can reflect whether a country's economy is experiencing growth and the extent of this growth. As such, GDP growth rate is also commonly regarded as a primary indicator for measuring economic growth. Hence, as a robustness check, we will replace the dependent variable from per capita GDP to GDP growth rate and then re-estimate Equation (3).

To mitigate potential endogeneity issue, following the approach outlined by Antonakis et al. (2014), we will employ two-stage least square (2SLS), as the third robustness check, to assess the impact of government digitization on economic growth. Specifically, referring to Fisman and Svensson (2007), we treat *GD* as an endogenous variable and select the mean of *GD* of other countries in the same region[5] for the current year as the instrumental variable (*IV*). Below are the justifications for the *IV* selection: (1) The digital development of other countries' governments typically cannot directly impact the economic growth of one's own country. As such, this *IV* meets the requirement of exogeneity; (2) The digital development of a country's government could be influenced by the digitization of governments of its surrounding countries. Specifically, the progress of neighboring countries in government digitization may be seen as an example for other countries in the region to emulate. This could lead to competition among neighboring countries in terms of government digitization, wherein each country strives to match or even surpass the government digitization level of its neighbors in order to maintain competitiveness. The data of *GD* is sourced from Division for Public Institutions and Digital Government of the United Nations, while the mean (i.e. *IV*) is calculated by the authors.

3.3.2. Mechanism tests

To test Hypotheses 1a and 1b, we will follow the methodology used by Wen et al. (2021) to conduct mechanism analysis by introducing two additional independent variables into Equation (3). Specifically, to examine whether government digitization can promote economic growth by suppressing corruption (i.e. Hypothesis 1a), as demonstrated in Equation (4), we introduced corruption control (*CC*) and the interaction term between government digitization and corruption control (*GD*CC*) into Equation (3). Following Kouladoum (2023), the corruption control index released by World Bank is used to measure *CC*, acquired from the Worldwide Governance Indicators (WGI) database. It should be emphasized that *CC* varies

[5] Following World Bank (2022), the world is divided into seven regions: East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa.

between –2.5 and 2.5. As such, this study will upscale the data of *CC* to positive digits, in order to facilitate the coefficient interpretation. To examine whether government digitization can enhance economic growth by decreasing the time required for businesses to access public services (i.e. Hypothesis 1b), as illustrated in Equation (5), we included the variable called time required (*TR*) and its interaction with government digitization (*GD***TR*) in Equation (3). Doing Business Reports 2004 to 2020 released by World Bank provide detailed data on the ease of doing business in 190 economies, including information on the time required for businesses to access public services (Corcoran & Gillanders, 2015). More specifically, these reports provide data on the time required to start a business, deal with construction permits, get electricity, register property, and enforce contracts in these 190 economies. As such, we use the arithmetic mean of the time required for these five behaviors to measure *TR*. It is worth noting that although the data provided by these reports span from 2003 to 2019[6], data on the time required to get electricity is only available from 2010 onwards. Consequently, the empirical test for Hypothesis 1b covers only the years 2011, 2013, 2015, 2017, and 2019.

$$Ln(GDP_{it}) = \alpha_0 + \alpha_1 GD_{it} + \alpha_2 CC_{it} + \alpha_3 (GD_{it} * CC_{it}) + \beta Z_{it} + \mu_i + \nu_t + \varepsilon_{it}; \quad (4)$$

$$Ln(GDP_{it}) = \alpha_0 + \alpha_1 GD_{it} + \alpha_2 Ln(TR_{it}) + \alpha_3 (GD_{it} * Ln(TR_{it})) + \beta Z_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (5)$$

3.3.3. Moderating effect analysis

To examine the moderating impact of telecommunications infrastructure (*TI*), basic education popularization (*BEP*), natural resource abundance (*NRA*), government efficiency (*GE*) and democracy (*Dem*) on government digitization's link with economic growth, that is Hypotheses 2 to 6, we will adopt a method similar to that employed by Jadiyappa et al. (2021). This involves dividing the 109 sample countries included in our study into 10 sub-samples based on the median values of these five moderating variables. Subsequently, we will estimate these sub-samples separately using Equation (3). If the five variables do indeed moderate the relationship between government digitization and economic growth, the results for the variable called *GD* are expected to differ across the estimations. Following Boyer-Wright and Kottemann (2015), telecommunication infrastructure index acquired from Division for Public Institutions and Digital Government of the United Nations is used to measure *TI*. In line with Wen et al. (2021), this study uses the gross rate of secondary school enrollment obtained from the WDI database to measure *BEP*. Following Ben-Salha et al. (2021), we use the percentage of total natural resources rents in GDP acquired from the WDI database as the proxy for *NRA*. In accordance with Ding et al. (2022), the estimate of government effectiveness obtained from the WGI database is considered as the proxy for *GE*. Referring to Neff and Pickard (2021), the democracy index provided by the Economist Intelligence Unit is utilized for measuring *Dem*. Similarly, to examine ruling party ideology's (*RPI*) moderation of the government digitization and economic growth relationship, that is Hypothesis 7, we will segment the sample into left- and right-wing administrations. Equation (3) will then be employed to analyze the sub-samples separately. As advised by Cotoc et al. (2021), we utilize the Database of Political Institutions by the IDB to collect information on *RPI*.

[6] Doing Business Reports actually provide the data of the previous year. For example, Doing Business Report 2020 provides data for 2019.

3.3.4. Quantile regression

To examine how the influence of government digitization on economic growth varies across the latter's stages (i.e. Hypothesis 8), we will conduct quantile regression. It is worth noting that quantile regression can not only examine the diversity of the impact across various economic development levels but also effectively overcome estimation bias caused by outliers (Syed et al., 2022). In line with Zheng et al. (2021), we will opt for five representative quantiles (i.e. 0.1, 0.25, 0.5, 0.75, and 0.9) for the quantile regression.

4. Results and discussion

4.1. Benchmark regression and robustness checks

The first and second columns in Table 2 present the findings of the benchmark estimation, where first column does not contain control variables and the second column contains them. It is observed that regardless of whether the control variables are included, the coefficient of *GD* is statistically significant and positive. This indicates that government digitization can significantly promote economic growth, confirming Hypothesis 1. This finding corroborates that of Majeed (2020) and Krishna and Sebastian (2021), both of whom emphasized the importance of government digitization in economic growth. Regarding the control variables, first, both *GFCF* and *TLF* obtained statistically significant positive coefficients, suggesting that fixed capital and labor force can notably boost economic growth. In line with this, the Cobb-Douglas production function identifies fixed capital and labor inputs as pivotal factors influencing economic development. The importance of fixed capital and labor force in economic development is further underscored by their marginal effects on economic growth. Specifically, among all control variables with positive coefficients, the coefficients of *GFCF* and *TLF* stand out for their magnitude, indicating that fixed capital and labor force exert a more pronounced stimulating effect on economic growth compared to other indicators. Second, according to Nguyen (2020), foreign direct investment can promote the economic growth of host countries by training local employees and introducing advanced production technologies and management concepts, which was empirically confirmed by Asongu et al. (2023). As such, the coefficient of *FDI* was predicted to be significantly positive. Contradicting this expectation, *FDI* obtained a statistically significant negative coefficient, indicating a suppressive effect of foreign direct investment on economic growth. The negative impact of foreign direct investment on economic growth could be related to profit repatriation[7] (Rahman, 2015). Supporting this, Helleiner (1989) contended that foreign direct investment serves as a mechanism through which western developed countries exploit and control developing countries. Third, consistent with Nguyen et al. (2022), the coefficient of *FD* is positive and significant, confirming that financial development contributes to economic growth. Fourth, *CPI*'s coefficient is also positive with significance at the 1% level. This result suggests that moderate inflation could contribute to economic growth (Uddin & Rahman, 2023). Specifically, moderate inflation reduces real interest rates, which helps promote capital invest-

[7] Profit repatriation refers to the return of foreign investment profits to the investing countries, rather than staying in the host countries for further investment and development.

ment and lending activities, and thus generates a favorable outcome on economic growth. Concurrently, moderate inflation can stimulate individuals to consume more in anticipation of price increases, thereby driving economic growth. Notably, as confirmed by He (2023), although mild inflation is beneficial for economic growth, excessive or unstable inflation can also lead to adverse economic consequences. As such, governments need to manage inflation cautiously. Finally, as indicated by endogenous growth theory, technological progress is the key factor of economic growth (Ding et al., 2023). Correspondingly, the coefficient of *RDE* is positive and has significance at the 1% level. This result aims to remind governments of the importance of increasing R&D investment in promoting economic growth.

The estimation results of the robustness checks can be found in the third to sixth columns of Table 2 and Table 3. The third and fourth columns present the outcomes of the placebo evaluation. It can be observed that the coefficients of *GD* reported in this test are not statistically significant. This rules out the possibility that the positive relationship between government digitization and economic growth revealed by the benchmark regression model is a placebo. The fifth and sixth columns in Table 2 reflect the estimation findings after replacing the dependent variable from per capita GDP to GDP growth rate. The coefficient of *GD* here was also positive and significant, which is consistent with the benchmark estimation results. This once again confirms the robustness of the benchmark estimation results.

Table 2. Benchmark model and robustness check results

	Fixed Effect		Placebo Test		Variable Replacement	
	I	II	III	IV	V	VI
GD	0.672***	0.353***	–0.038	–0.007	0.102***	0.050***
	(15.69)	(8.74)	(–1.12)	(–0.32)	(9.19)	(4.76)
GFCF		0.415***		0.184		0.119***
		(2.96)		(1.25)		(3.29)
TLF		0.329***		0.463***		0.010
		(4.53)		(6.09)		(0.52)
FDI		–0.062**		–0.047*		–0.003
		(–2.50)		(–1.79)		(–0.51)
FD		0.117***		0.130***		–0.012***
		(9.73)		(10.22)		(–3.88)
CPI		0.116***		0.162***		–0.024***
		(7.41)		(10.25)		(–5.97)
RDE		0.112***		0.129***		–0.020***
		(4.31)		(4.67)		(–2.95)
Constant	8.661***	2.868**	9.051***	0.855	0.176***	0.022
	(354.23)	(2.57)	(450.70)	(0.73)	(33.68)	(0.08)
R-squared	0.303	0.597	–0.038	0.561	0.281	0.542
country FE	YES	YES	YES	YES	YES	YES
year FE	YES	YES	YES	YES	YES	YES

Note: t-statistics are shown in parenthesis; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The results of 2SLS estimation employed to alleviate the potential endogeneity are presented in Table 3. According to the results, it can be found that *IV* obtained a statistically significant positive coefficient, suggesting that a country's level of government digitization is positively influenced by the government digitization levels of its neighboring countries. The F statistic in Column I is 37.32, which is far greater than 10, indicating that the instrumental variable selected in this study was not weak. Notably, *GD*'s coefficient in Column II also had statistical significance and a positive sign, reaffirming the positive influence of government digitization on economic growth as indicated by the benchmark estimation results.

Table 3. 2SLS robustness check

	I	II
IV	0.015***	
	(3.05)	
GD		0.181***
		(2.87)
GFCF	–0.291**	0.105***
	(–2.39)	(3.46)
TLF	0.009	0.763**
	(1.52)	(2.32)
FDI	0.007	–0.450
	(0.25)	(–0.29)
FD	0.049***	–1.876
	(11.21)	(–0.38)
CPI	0.149***	–6.698
	(9.90)	(–0.46)
RDE	0.049***	2.057*
	(4.80)	(1.82)
R-squared	0.527	0.561
country FE	YES	YES
year FE	YES	YES
F statistic	37.32	

Note: t-statistics are shown in parenthesis; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

4.2. Mechanism tests

The results of the mechanism tests, conducted by estimating Equations (4) and (5), are displayed in Table 4. The estimated outcomes of Equation (4) are presented in the first and second columns. It can be observed that *CC* in Column I demonstrated a positive and significant coefficient at the 1% level. This underscores the vital role of corruption control in promoting economic growth, which is consistent with Cieślik and Goczek (2018). Furthermore, the results from Column II, which incorporates the interaction term *GD*CC*, provide a valuable insight. Specifically, the positive and significant coefficient exhibited by *GD*CC* suggests that the enhancement of government digitization indeed promotes economic growth by curbing corruption, confirming Hypothesis 1a. This finding highlights the synergistic role of govern-

ment digitization and corruption control in promoting economic growth, aiming to remind governments of the need to simultaneously focus on implementing government digitization initiatives and undertaking anti-corruption actions to create an environment conducive to economic growth.

The estimation results of Equation (5) are reported in Columns III and IV. The coefficient of *TR* in the third column is negative and statistically significant, indicating a negative relationship between enterprises spending more time accessing public services and economic growth. This finding emphasizes the adverse impact of inefficient bureaucratic institutions on economic growth (Azam, 2022). Meanwhile, the coefficient of *GD*TR* in Column IV is positive and has significance at the 1% level. This suggests that the enhancement of government digitization can promote economic growth by reducing the time needed for businesses to access public services, thus confirming Hypothesis 1b.

Table 4. Mechanism tests

	Corruption control		Time to obtain public services	
	I	II	III	IV
GD		0.154***		0.213**
		(8.03)		(2.56)
GFCF	0.122	0.373***	–0.023	0.517
	(0.85)	(2.74)	(–0.06)	(1.33)
TLF	0.560***	0.438***	–0.064	–0.216
	(7.33)	(6.05)	(–0.30)	(–1.03)
FDI	–0.050*	–0.054**	–1.285***	–1.415***
	(–1.95)	(–2.25)	(–3.90)	(–4.44)
FD	0.130***	0.114***	0.173***	0.170***
	(10.51)	(9.88)	(5.68)	(5.95)
CPI	0.155***	0.099***	0.116***	0.088***
	(9.99)	(6.35)	(5.47)	(4.10)
RDE	0.128***	0.110***	0.173	0.099
	(4.77)	(4.39)	(1.61)	(0.99)
CC	0.184***	0.229***		
	(5.24)	(6.28)		
GD*CC		0.130***		
		(3.74)		
TR			–0.192**	0.378
			(–2.15)	(1.07)
GD*TR				0.094***
				(2.89)
Constant	–0.964	0.799	8.451***	9.876***
	(–0.81)	(0.71)	(2.65)	(2.65)
R-squared	0.562	0.626	0.760	0.797
country FE	YES	YES	YES	YES
year FE	YES	YES	YES	YES

Note: t-statistics are shown in parenthesis; ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

4.3. Moderating effect analysis

The estimation results of the moderating effect analysis, corresponding to Section 3.3.3, are presented in Table 5. The first and second columns respectively present the results of the two sub-samples of countries with relatively underdeveloped telecommunications infrastructure and countries with relatively well-developed telecommunications infrastructure. *GD* in both columns obtained statistically significant positive coefficients. This indicates that regardless of whether a country's telecommunications infrastructure is developed or not, the improvement of government digitization can promote the country's economic growth. However, from the perspective of marginal effects, the coefficient obtained by *GD* in Column II is greater than that obtained by *GD* in Column I, indicating that government digitization has a stronger promoting effect on economic development in nations with more complete telecommunications infrastructure. In other words, when national telecommunications infrastructure improves, the promotion effect of government digitization on national economic growth is more robust, meaning that telecommunications infrastructure positively moderates the government digitization-economic growth link. As such, Hypothesis 2 is validated.

The third and fourth columns respectively present the estimations of the two sub-samples of countries with relatively low basic education popularization rates and countries with relatively high basic education popularization rates. It can be observed that although *GD* in both columns obtained statistically significant positive coefficients, the value in the fourth column is larger than the one in the third column. This indicates that with the improvement of basic education popularization, the positive influence of government digitization on economic growth tends to be stronger, that is, the popularization of basic education positively moderates the government digitization-economic growth link. As such, Hypothesis 3 is confirmed. This finding underscores the crucial role of basic education in shaping the relationship between government digitization and economic growth. Supporting this, Nadezhina and Avduevskaia (2021) argued that investment in education can amplify the economic benefits of digitization.

The fifth and sixth columns respectively report the results of estimating the two sub-samples of countries with relatively scarce natural resources and countries with relatively abundant natural resources. We can find that *GD* obtained statistically significant positive coefficients in both columns, but the value in Column VI is smaller than that in Column V. This suggests that compared to countries with relatively abundant natural resources, government digitization has a stronger promoting effect on economic growth in those with relatively scarce natural resources. In other words, as a country's natural resource richness increases, the role of government digitization in promoting economic growth tends to weaken, that is natural resource abundance can negatively moderate the government digitization-economic growth link. As such, Hypothesis 4 is validated. This finding is consistent with the theory of resource curse, wherein abundant natural resources could lead to adverse economic consequences because governments could excessively rely on the lucrative returns from natural resource trading, neglecting the long-term role of technological innovation in economic growth (Alssadek & Benhin, 2023).

Table 5. Moderating effect analysis

	Telecommunications infrastructure		Basic education popularization		Natural resource abundance		Government efficiency		Democracy		Ruling party ideology	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
GD	0.149***	0.326***	0.217***	0.398***	0.298***	0.195***	0.145***	0.388***	0.235***	0.182***	0.048	0.124***
	(4.70)	(5.38)	(3.87)	(6.23)	(4.77)	(4.56)	(3.48)	(4.91)	(3.64)	(3.81)	(0.76)	(2.98)
GFCF	0.706***	0.900***	0.800***	0.281	1.208***	0.954***	0.772***	1.497***	0.142	1.685***	0.616***	1.366***
	(3.92)	(4.70)	(3.21)	(1.52)	(7.00)	(3.70)	(3.67)	(7.33)	(0.58)	(5.10)	(2.82)	(5.77)
TLF	0.166	0.554***	0.467***	0.422***	0.283***	0.397***	0.345***	0.006	0.165	0.282	0.719***	–0.006
	(1.40)	(8.64)	(4.29)	(3.29)	(3.47)	(3.69)	(3.15)	(0.08)	(0.76)	(1.54)	(4.15)	(–0.05)
FDI	–0.974***	–0.051**	–0.027	–0.072	–0.038**	–1.690***	–1.500***	–0.032*	0.294	0.025	0.141**	–0.017
	(–5.15)	(–2.50)	(–0.97)	(–1.55)	(–2.03)	(–6.79)	(–6.76)	(–1.85)	(0.74)	(0.78)	(2.19)	(–1.10)
FD	0.177***	–0.010	0.110***	0.073***	0.065***	0.116***	0.216***	0.018	0.079*	–0.059**	–0.008	0.004
	(10.53)	(–0.99)	(5.29)	(4.83)	(4.90)	(6.58)	(10.24)	(1.60)	(1.81)	(–2.47)	(–0.43)	(0.25)
CPI	0.222***	0.067**	0.021	0.164***	0.367***	0.079***	0.116***	0.531***	0.017	0.284***	0.303***	0.472***
	(6.44)	(2.52)	(0.92)	(7.97)	(10.83)	(4.59)	(6.16)	(11.56)	(0.66)	(3.67)	(5.42)	(8.29)
RDE	0.172**	0.098***	0.232***	0.081***	0.076***	0.072	0.066	0.114***	0.075	–0.045	–0.081	0.044
	(2.57)	(5.99)	(4.19)	(2.70)	(3.14)	(1.46)	(0.88)	(4.57)	(1.08)	(–1.21)	(–1.61)	(1.12)
Constant	4.434**	0.824	0.121	2.194	4.060***	1.151	1.598	8.396***	5.315	5.315*	–2.499	8.685***
	(2.39)	(0.85)	(0.07)	(1.12)	(3.34)	(0.68)	(0.94)	(7.11)	(1.56)	(1.90)	(–0.95)	(4.96)
R-squared	0.728	0.572	0.640	0.508	0.676	0.665	0.775	0.683	0.397	0.521	0.802	0.759
country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: t-statistics are shown in parenthesis; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The seventh and eight columns respectively exhibit the estimation outcomes for the two sub-samples of countries with relatively low government efficiency and countries with relatively high government efficiency. It can be observed that *GD* obtained statistically significant positive coefficients in both columns, but the coefficient in Column VIII is larger than that in Column VII. This indicates that when government efficiency is higher, government digitization can more significantly stimulate economic growth. In other words, government efficiency has a positive moderating effect on the government digitization-economic growth link, and Hypothesis 5 is therefore confirmed. Supporting this, Jiménez et al. (2022) pointed out that digitization tends to yield greater returns in an environment characterized by high institutional quality and governance effectiveness.

Columns IX and X respectively present the estimation results for countries with relatively low and high levels of democracy. The results indicate that although *GD* obtained statistically significant positive coefficients in both columns, the value in Column X is smaller than that in Column IX. This suggests that as a country's level of democracy increases, the promoting effect of government digitization on its economic growth diminishes, that is democracy can negatively moderate the government digitization-economic growth link. Thus, Hypothesis 6 is validated. As previously mentioned, this disappointing finding could be attributed to the decentralized political power in democratic countries, which might hinder the advancement of government digitization. Consequently, this underscores the need for relevant countries to adopt more flexible and adaptive strategies to promote the digitization process.

The comparison between countries governed by left-wing and right-wing parties reveals interesting insights. In countries where left-wing parties hold power (Column XI), the coef-

ficient obtained by *GD* lacks statistical significance, suggesting that under the governance of left-wing parties, government digitization fails to significantly bolster economic growth. Conversely, in countries where right-wing parties are in control (Column XII), the statistically significant positive coefficient for *GD* indicates a significant positive impact of government digitization on economic growth. These results lend support to Hypothesis 7, suggesting that ruling party ideology can significantly influence the effectiveness of government digitization in driving economic growth. This could remind left-wing parties to focus more on digitization construction, in order to create favorable conditions for economic growth.

4.4. Quantile regression

The quantile regression results are displayed in Table 6. Across all five quantiles, *GD* consistently exhibits a statistically significant positive coefficient. This suggests that irrespective of the economic development stage, government digitization plays a significant positive role in fostering economic growth, which once again confirms Hypothesis 1. Moreover, it is noticeable that as the quantile increases, the coefficients obtained by *GD* initially rise before declining. This suggests that as the economic level improves, the positive influence of government digitization on economic growth exhibits a pattern of initially increasing and subsequently decreasing, thus verifying Hypothesis 8. These results confirm the complexity of the relationship between government digitization and economic growth at different stages of economic development, and can remind governments of the importance of tailoring government digitization policies to local conditions to ensure that each country's policies can meet the specific needs of its own development stage.

Table 6. Quantile regression

	QR_10	QR_25	QR_50	QR_75	QR_90
	I	II	III	IV	V
GD	0.151***	0.690***	0.403***	0.341***	0.337***
	(4.20)	(6.16)	(7.32)	(6.21)	(7.89)
GFCF	0.142***	0.381***	0.699***	0.406***	0.390***
	(2.60)	(2.97)	(3.10)	(3.02)	(2.96)
TLF	0.220***	0.304***	0.777***	0.331***	0.318***
	(3.55)	(4.04)	(5.32)	(4.70)	(4.15)
FDI	0.017	–0.046	–0.016	–0.129	–0.113
	(0.11)	(–0.28)	(–0.13)	(–1.05)	(–1.27)
FD	0.048***	0.063***	0.071***	0.103***	0.110***
	(5.33)	(6.94)	(6.98)	(8.28)	(9.95)
CPI	0.131	0.033	–0.006	–0.024	–0.059
	(1.42)	(0.36)	(–0.08)	(–0.34)	(–1.17)
RDE	0.255***	0.214***	0.227***	0.163***	0.123***
	(4.26)	(3.58)	(5.12)	(3.64)	(3.79)
country FE	YES	YES	YES	YES	YES
year FE	YES	YES	YES	YES	YES

Note: t-statistics are shown in parenthesis; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusions

5.1. Summary of findings and policy implications

This paper aims to investigate the impact of government digitization on economic growth, which provides a theoretical framework based on the Cobb-Douglas production function and conducts a series of empirical tests. First, we employed a fixed effect model for the benchmark estimation to empirically analyze panel data from 109 countries spanning from 2002 to 2021. The estimation results indicate that government digitization can significantly promote economic growth. Furthermore, this promoting effect withstands scrutiny from multiple robustness checks. Next, we utilized fixed effect models containing interaction terms to examine the mechanism through which government digitization affects economic growth. The results suggest that government digitization can stimulate economic growth by curbing corruption and shortening the time required for businesses to access public services. Third, we divided the sample into sub-samples to conduct heterogeneity analysis, and confirmed the moderating effects of telecommunications infrastructure, basic education coverage, natural resource abundance, government efficiency, democracy, and ruling party ideology on the government digitization-economic growth link. Specifically, when a country has more advanced telecommunications infrastructure, higher basic education coverage, scarcer natural resources, more efficient government, more authoritarian politics, and is governed by a right-wing party, the positive effect of government digitization on economic growth tends to be stronger. Finally, we employed quantile regression to explore the diversity of this impact across different stages of a country's economic development, and found that with the improvement of the national economy, the promoting influence of government digitization on economic growth shows a pattern of first increasing and then decreasing.

This study's findings offer countries insights for advancing their economic growth. First, given the positive influence of government digitization on economic growth, governments worldwide should accelerate their own digital transformation, continually enhancing their digital service capabilities. Second, considering the confirmed positive moderating effects of telecommunications infrastructure, basic education popularization, and government efficiency, governments should strengthen the roles of these three moderating factors: (1) Governments could increase their investment in telecommunications infrastructure, promoting the expansion of network coverage and the improvement of internet speed, in order to ensure that businesses and citizens can conveniently access digital services provided by governments; (2) Governments could increase their basic education investment to improve the popularity of digital skills, enabling more people to access public services through digital platforms; (3) Governments should focus on improving their own administrative efficiency, which can be achieved through enhancing the educational attainment of government staff, optimizing institutional environments, and fostering service-driven governance. Third, given the negative moderating effect of natural resource abundance on the government digitization-economic growth link, which could be attributable to the resource curse, relevant countries should lessen their dependence on natural resources and ensure that government digitization initiatives receive due attention. Fourth, given that democracy can weaken the positive effect of government digitization on economic growth, which could be associated with the political power decentralization caused by democratic politics, relevant countries could consider

strengthening the centralization of government digitization efforts to ensure more efficient implementation of these measures. Fifth, in light of ruling party ideology's moderating effect on the government digitization-economic growth link, countries could establish independent institutions to regulate government digital construction to prevent it from being manipulated by political interests. Finally, considering the differences in the promotion intensity of government digitization on economic growth at different stages of economic development, countries worldwide should formulate differentiated government digitization strategies based on their own economic development situations. Specifically, compared to economically stronger countries, those with relatively weaker economic development levels are in greater need to prioritize increasing investment in digital infrastructure and digital talents to accelerate government digitization process and enhance economic development levels.

5.2. Limitations of the study

Despite our rigorous efforts to undertake this research meticulously, certain limitations persist and await resolution. First, constrained by data availability, this study only includes 109 countries. If more data from additional countries becomes available in the future, researchers can expand upon this study. Furthermore, despite our investigation into the mechanisms of the government digitization-economic growth link from the perspectives of corruption control and the time needed for businesses to access public services, it must be acknowledged that there could still be undiscovered mechanisms. As such, researchers can further explore this aspect.

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APPENDIX

List A1. The country list

Albania, Algeria, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Democratic Republic of the Congo, Denmark, Ecuador, Egypt, El Salvador, Estonia, Eswatini, Ethiopia, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Iran (Islamic Republic of), Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lesotho, Lithuania, Luxembourg, Madagascar, Malaysia, Mali, Malta, Mauritius, Mexico, Mongolia, Morocco, Nepal, New Zealand, Nicaragua, North Macedonia, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Tajikistan, Thailand, Tunisia, Türkiye, Uganda, Ukraine, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Viet Nam.