Politická ekonomie

Volume 74
Forthcoming articles
https://doi.org/10.18267/j.polek.1518
Open Access

PRAGUE UNIVERSITY OF ECONOMICS AND BUSINESS

How do digital government and digital finance promote green investment?

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Abstract

In order to tackle climate change and global warming, policymakers all around the globe have stressed fostering investment in green initiatives and projects. Particularly in top polluted economies, the importance of green investment has recently increased manifold. Thus, researchers have focused on finding the determinants of green investment. This analysis aims to scrutinize the link between digital government, digital financial inclusion, and green investment nexus in top polluted economies by employing two-stage least squares (2SLS), generalized method of moments (GMM), and smoothed instrumental quantile regression (SIVQR) methods. In addition to analysing an aggregate sample of top polluted economies, we have performed a regional analysis by disaggregating the data. The findings reveal that digital financial inclusion boosts green investment in the full sample, Asia, America, Europe, and Africa, while the digital government promotes green investment in all regions except Africa. The control variables of GDP, carbon emissions, foreign direct investment, and human capital foster green investment in top polluted economies, while trade reduces green investment in these economies. On the policy front, an integrated approach with a central focus on digital governance and financial inclusion is required to boost green investment.

Keywords: Digital government, green investment, digital finance

JEL Classification: H11, O13, O16, P45

1. Introduction

Life on the planet is in danger due to the growing menace of climate change. The rising GHG emissions, particularly CO_2 emissions, are acknowledged as the major driver of climate change. Industrial revolution is believed to be the starting point of climate change as industrialization is the major contributor to global carbon footprints despite its positive role in uplifting the living standards of people worldwide (Penna, 2014). Since the start of industrial revolution, industries have mostly relied on carbon fuels such as coal, oil, and gas, which are the primary contributors to deteriorating environmental quality. In addition, the process of industrialization caused massive deforestation and extraction of natural resources, leading to higher carbon intensity within the ecosystem in the last thirty years. The Intergovernmental Panel on Climate Change (IPCC) report has warned world leaders about the most severe catastrophic impacts of climate change in the coming years if the trend of growing carbon intensity persists (IPCC, 2022). In this context, the pressure is mounting on the world leaders to work jointly to mitigate the mounting CO_2 intensity. In response to the escalating pressure, the world leaders sat together, in 2015 in Paris, and signed a treaty that binds them to curtail the increase in global temperature to 1.5°C over pre-industrial levels to protect the planet from the awful consequences of global warming (Fu *et al*., 2018). Among the several options to enhance environmental quality and reduce CO_2 intensity, investing in green energy and innovations is the most celebrated option in the eyes of environmentalists and policy experts (van den Bergh, 2013). According to the existing literature, green investment is helpful in mitigating carbon intensity (Li *et al*., 2021). However, not much is known about the determinants of green investment in current scholarly literature. This analysis aims to bridge this gap by examining the nexus between digital government, digital financial inclusion, and green investment.

To achieve superior environmental and economic performance, it is vital to allocate sufficient funds for sustainable transformation of the economic structure (Ren *et al*., 2022). The desired results can be achieved by fostering financial activities that boost investment in diverse fields, including renewable energy, eco-innovations, and bio-goods. This type of investment is commonly known as green investment (Eyraud, 2013). Given the significance of green investments in achieving sustainability, there has been a significant rise in green investment worldwide since the start of the 21st century. Despite its popularity, the level of green investment remains unsatisfactory (Clark *et al*., 2019). The European Environmental Agency (EEA, 2023) claimed that in order to successfully transform into a low-carbon global economy by 2030, the world needs to invest in green technologies and energies at a much higher rate. Another organization, known as the G20 Green Finance Study Group, has also called on the G20 leaders during their 2016 meeting held in China to pass on cash from environmentally harmful investments to eco-friendly ones (Ma *et al*., 2023).

The present era is referred to as the age of technology, where global socioeconomic progress is largely due to technological development. The expansion of information and communication technology (ICT) has significantly improved development procedures and transformed each and every sector of the economy, as well as the government sector (Chatterjee, 2020). Digital government relies on digitalization and ICT to perform daily operations and to formulate policies. The World Bank (2022) defines digital government as the use of information technologies, by government agencies to transform their interactions with citizens, businesses, and other government branches. There are several benefits of utilizing ICT in government services. For instance, it may facilitate the adoption of wide-ranging plans and public services while also encouraging a well-functioning and transparent organizational structure (Clifton *et al.*, 2020). A 2016 study by the United Nations on e-government highlights that increased reliance on the e-government may help in achieving sustainable development by enabling the real-time supervision of green projects and innovations, which in turn boosts investment in green initiatives (Castro and Lopes, 2022).

Moreover, the means of interaction between government and the public have become more modernized and sophisticated due to increased reliance on digitalization. Also, this process aids in the speedy dissemination of information about the government efforts to promote green investment. Consequently, individuals and businesses will show more interest in eco-friendly production and consumption activities and start investing in green energy and technology. Indeed, the significance of digital government has been widely praised for its role in fostering transparency, accountability, citizen involvement (Janowski, 2015) and encouraging economic development (Khan and Majeed, 2019); there is a dearth of literature on the impact of digital government on green investment.

The actions of digital government to promote green investment do need support from the financial sector, which has become more digitalized and inclusive due to the increased use of ICT. According to Polzin and Sanders (2020), the financial sector is a key driver in a transition toward a low-carbon economy by promoting investment in clean and green projects. Support from the financial sector is crucial to provide the total green investment of US$ 100 billion that is required to achieve sustainable development goals alongside the objectives of Paris Accord (Sachs *et al.*, 2019). As far as digital financial inclusion is concerned, it is widely recognized as a factor of environmental quality because it makes investments in clean and green energy more conducive, accessible, and affordable. It removes the hurdles in attaining loans from financial institutions and encourages businesses to invest in eco-friendly technologies (Sun *et al.*, 2022). The expansion of digital financial inclusion boots corporate environmental, social, and government performance, which helps increase the development of green technologies (Xue and Zhang, 2022). The popularity of digital financial inclusion has encouraged more researchers to estimate its impact on the economic and environmental performance of different nations and regions (Ozturk and Ullah 2022; Singh *et al.*, 2023). However, the empirical literature on the nexus between digital financial inclusion and green investment is still in its infancy. Based on the literature, the following hypotheses are proposed:

H_1: *Digital government has a positive impact on green investment.*

H_2: *Digital finance significantly promotes green investment.*

The study's primary objective is to investigate the impact of digital government and digital financial inclusion on green investment. Thus, the study is a valuable addition to the existing literature in the following ways. First and foremost, no empirical study in the past has examined the role of digital government and digital financial inclusion in the expansion of green investment. This study bridges the gap and becomes the first study to analyze the impact of digital government and digital financial inclusion on green investment. Therefore, this study can prove vital in providing the empirical and theoretical base for future studies in this regard. Second, combining these two factors in a green investment function can provide valuable insights into the integration of digital technologies into the government and financial sectors and their role in promoting green investment. Third, the study employs the 2SLS, GMM, and SIVQR approaches to counter the issues of endogeneity and thus produce robust estimates. Lastly, the study results are vital for policy experts and entrepreneurs in designing policies to boost green investment by focusing on the combination of digital government and digital financial inclusion as important policy tools.

2. Empirical model

This study investigates the influence of digital government and digital financial inclusion on green investment. We constructed the following panel data econometric model:

$$GI_{it} = \pi_0 + \pi_1 DG_{it} + \pi_2 DFI_{it} + \pi_3 GDP_{it} + \pi_4 CO2_{it} + \pi_5 FDI_{it} + \pi_6 Trade_{it} + \pi_7 HC_{it} + \pi_8 NRR_{it} + \alpha_i + \varepsilon_{it} \quad (1)$$

In equation (1), the term GI refers to the green investment in country i, where i ranges from 1 to 71, observed during time t from 1 to 15. Simultaneously, GI are determined by digital government (DG), digital financial inclusion (DFI), GDP per capita (GDP), carbon dioxide emissions (CO_2), foreign direct investment (FDI), trade openness ($Trade$), human capital (HC), natural resources rents (NRR). While ε_{it} represent error term, ai gauges the unobserved effect in the model. The parameters π_1, π_2, …, and π_8 represent the outcome elasticities concerning their respective factor inputs. The potential sign of the DG may turn out to be positive. This is because digital government activities may improve the management of ecological values, leading to a more favorable environment for investment in green initiatives and projects by ensuring that businesses follow sustainable practices. Moreover, digital government can help remove bureaucratic barriers by allowing investors to apply for green investment projects online. The possible effect of *DFI* on green investment may be positive. It is widely believed that the financial sector is vital in providing the necessary initial investment for risky green projects. Consequently, a more digitalized and inclusive financial sector increases the accessibility to financial resources manifold, thus allowing individuals and enterprises to acquire capital for investment in green projects at a much faster and more affordable rate.

3. Methods of estimation

For estimating the influence of digital government and digital finance on green investment we utilize several approaches including the 2SLS proposed by Cumby *et al*. (1983), the GMM of Arellano and Bover (1995) and Blundell and Bond (1998), and SIVQR of Kaplan (2022). These approaches have one thing in common: they use instruments to control endogeneity, a common concern of panel analysis. However, the selection of these instruments is a headache for researchers due to complexities involved in the process. We tackled this situation by using a general approach to instrument selection, using every regressor as instruments in the analysis. While the study used *DFI* variables as endogenous. In addition to 2SLS, we also applied the GMM technique. GMM approaches were first developed by Hansen (1982) and subsequently refined by Holtz-Eakin *et al*. (1988), whereas Arellano and Bond (1991) advocated for the difference GMM. The difference-GMM estimator is designed for datasets characterized by many panel units (i) and limited time (t). The system-GMM, an improved version, was presented by Arellano and Bover (1995) and advanced by Blundell and Bond (1998). The system-GMM establishes additional orthogonality constraints that provide accurate instruments and enhance efficiency. System GMM mitigates issues of heteroskedasticity, omitted variable bias, endogeneity among variables, and autocorrelation (Abdallah *et al*. 2015). This work utilizes system GMM to assess the association between digital government, digital financial inclusion, and green investment, considering the challenges related to dynamic panel data and the limitation of other dynamic panel data estimators, such as first difference and the within-group estimator. This research selects the system-GMM over the difference-GMM estimator because the system-GMM provides accurate and efficient estimates, addresses the endogeneity problem, and is more suitable for panel investigations due to its ability to reduce bias (Blundell and Bond, 1998). In the GMM model, the study used the Hansen test to check if our instruments are valid. Also, the AR(2) test is applied for serial correlation in the model.

All of the methods share one drawback, they are ineffective if they have to face anyone of the following situations: extreme data points, outliers, and non-normal data (Wattanawongwan *et al*. 2023). Quantile regression approaches are the solutions to these problems, but these approaches fail in the case of endogeneity. Thus, Chernozhukov and Hansen (2008) introduce an integrated approach having the characteristics of both quantile regression and instrumental variable referred to as instrumental variable quantiles regression (IVQR), which provides reliable estimates in the presence of endogeneity. The inclusion of instrument variable to control endogeneity makes the conventional quantile regression approaches better. Nevertheless, the SIVQR of Kaplan (2022) is advanced and improved version of the IVQR due to its ability to include more than one endogenous variable. Therefore, we have selected the SIVQR to check the robustness of our estimates.

4. Data and descriptive analysis

To explore the nexus between digital government, digital financial inclusion, and green investment, our study used panel dataset for 71 polluted economies from 2007 to 2021. The list of sample countries is presented in the appendix (see, Table A1). Green investment (*GI*) is the dependent variable in our model. Following Alsagr and Ozturk (2024), total production from nuclear, renewables, and other sources have been used as a proxy measure for green investment (*GI*) for which data is obtained from the Energy Information Administration (EIA). The renewable energy production of the top-producing nations is shown in Figure 1. Digital government (*DG*) and digital financial inclusion (*DFI*) are major focused variables in our model. Digital government (*DG*) is measured through E-government development index, which the United Nations (UN) has formulated. Digital financial inclusion (*DFI*) is measured by an index formulated by the authors. *DFI* index includes three determinants, such as ATM per 1,000,000 adults, Debit card (% age 15+), Bank branches per 100,000 adults. The variables used for developing the *DFI* index are supported by IMF (IMF, 2021) and empirical literature (Alsagr *et al*. 2024; Hongzuo *et al*. 2025) as crucial components for digital financial inclusion. The principal components analysis is used to develop the *DFI* index. The datasets for the index are provided by Global Financial Development Database (GFDD)[1]. GDP per capita (constant 2015 US$), CO_2 emissions (in kilotons), foreign direct investment (net inflows as percent of GDP), trade openness (as % of GDP), human capital measured by secondary school enrollment (gross %), natural resource rents (as % of GDP) are used as control variables in our model. Selection of control variables is made from prior literature (see Liao 2018; Wen *et al*. 2023). The data series for *GDP*, CO_2, *FDI*, Trade, *HC*,

1 https://databank.worldbank.org/source/global-financial-development

and *NRR* have been taken from the World Development Indicators (WDI). Taking natural log of all the variables have several advantages. First, it normalizes the data by reducing the difference between maximum and minimum values. Second, makes the interpretation of the estimates easy by neutralizing the units of the variables. Due to these advantages, we have also taken the variables' natural log. The definitions and data description of variables are given in Table 1. The regression analysis is carried out using Stata 17 software.

Table 1: Definitions and data description

Variable	Definitions	Sources	Mean	SD	Min	Max
Green investment (*GI*)	A proxy of renewables energy production (quad Btu)	EIA[1]	0.994	2.907	0	24.91
Digital government (*DG*)	E-government development index value	UN[2]	0.607	0.183	0.224	1.006
Digital financial inclusion (*DFI*)	Digital financial inclusion index (ATM per 1,000,000 adults, Debit card (% age 15+), Bank branches per 100,000 adults)	Authors' own calculations	3.294	0.96	−0.007	5.880
GDP per capita (*GDP*)	GDP per capita (constant 2015 US$)	WDI[3]	8.989	1.224	6.454	11.37
Carbon dioxide emissions (CO_2)	CO_2 emissions (kt)	WDI[4]	11.30	1.558	7.897	16.22
Foreign direct investment (*FDI*)	FDI, net inflows (% of GDP)	WDI[4]	0.911	1.089	−4.837	4.692
Trade openness (*Trade*)	Trade (% of GDP)	WDI[4]	4.258	0.533	1.565	6.081
Human capital (*HC*)	School enrollment, secondary (% gross)	WDI[4]	4.474	0.309	3.008	5.099
Natural resources rents (*NRR*)	Total natural resources rents (% of GDP)	WDI[4]	4.461	7.332	−28.6	52.56

Source: Authors' own calculations[2,3,4]

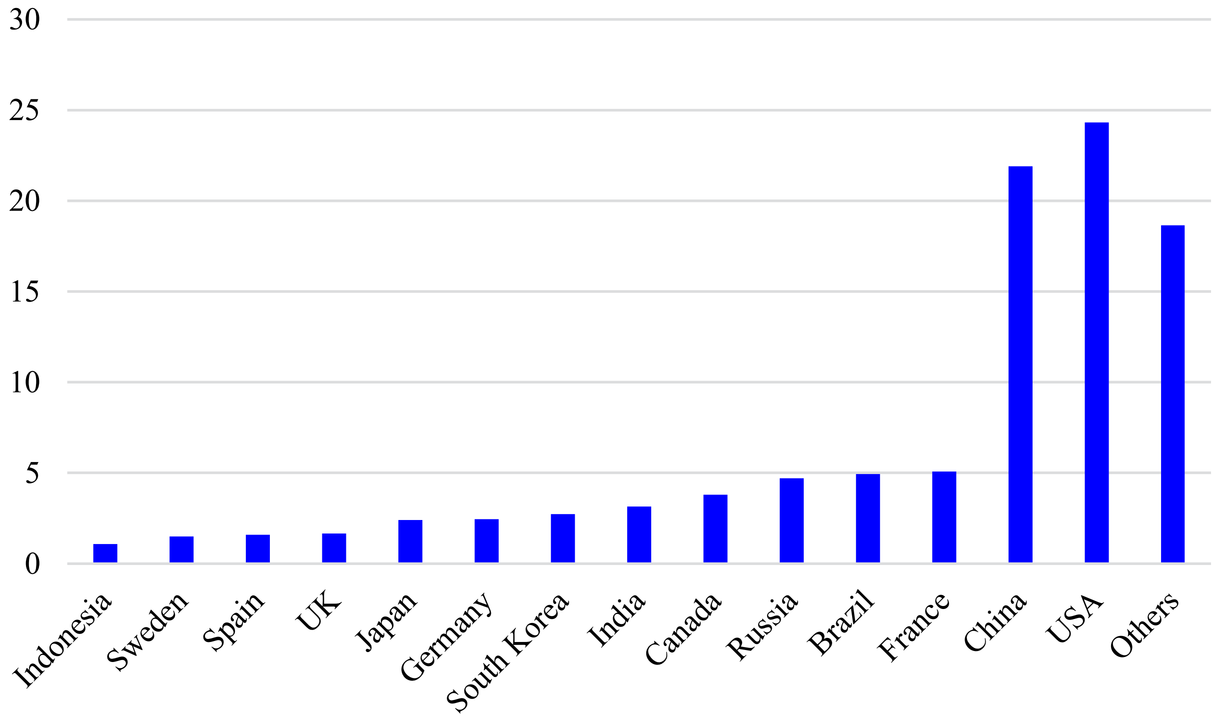
2 https://www.eia.gov/international/data/world/total-energy/total-energy-production

3 https://publicadministration.un.org/egovkb/en-us/Data-Center

4 https://databank.worldbank.org/source/world-development-indicators

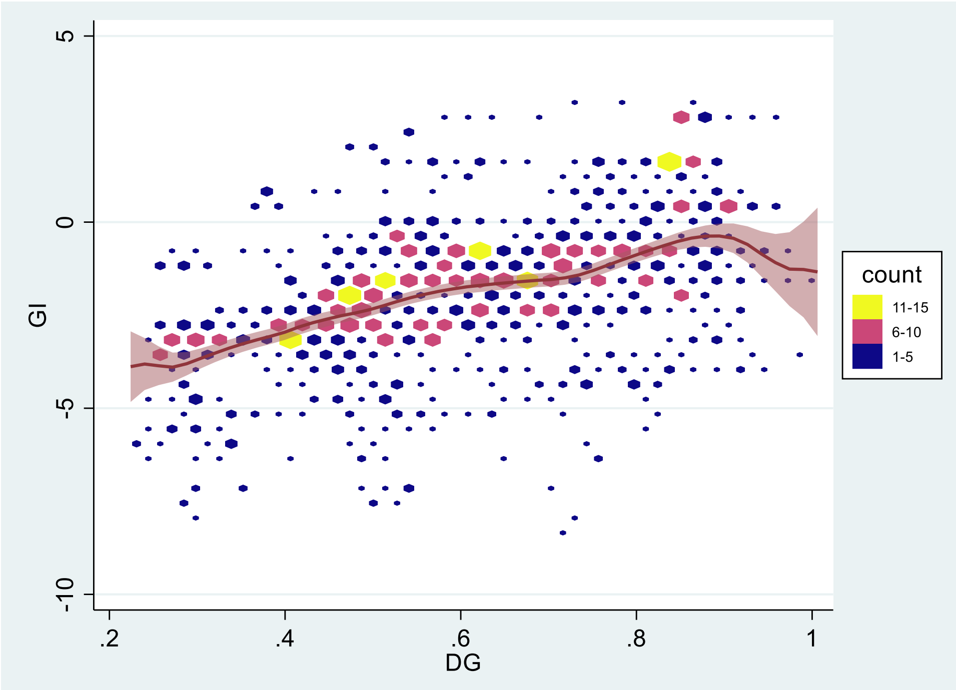
Table 1 reports variables' mean and standard deviations with maximum and minimum ranges. Highest mean score is found for CO_2 (11.3), and minimum mean score is noted for *DG* (0.607). The mean scores for *GI*, *DFI*, *GDP*, *FDI*, *HC*, and *NRR* are 0.994, 3.294, 8.989, 0.911, 4.258, 4.474, and 4.461, respectively. The standard deviation scores for *GI*, *DG*, *DFI*, *GDP*, CO_2, *FDI*, *Trade*, *HC*, and *NRR* are 2.907, 0.183, 0.96, 1.224, 1.558, 1.089, 0.533, 0.309, 7.332, respectively. The scatterplot in Figure 2 illustrates a robust positive correlation between digital government and green investment. A similar relationship is obvious in Figure 3 for digital financial inclusion and green investment.

Figure 1: Share of renewable energy production (in %)



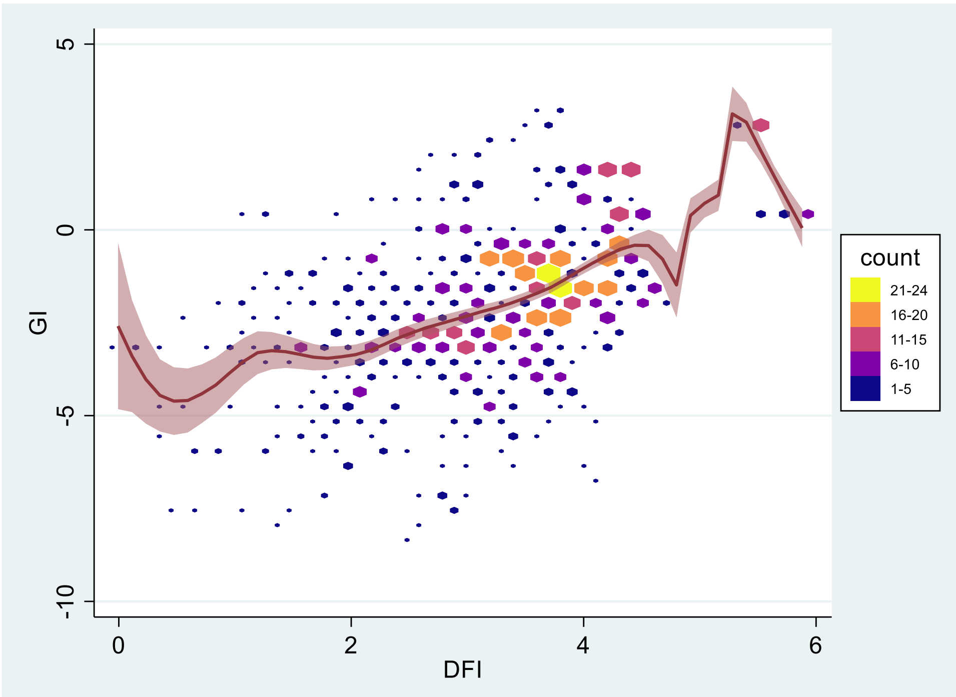
Source: Authors' own elaboration based on EIA (2023) database

Figure 2: Hexagons correlations between digital government and green investment



Source: Authors' own elaboration

Figure 3: Hexagons correlations between digital financial inclusion and green investment



Source: Authors' own elaboration

5. Empirical results and discussion

The panel analysis normally starts by checking whether the variables included in the model are stationary or non-stationary. Checking the unit root is crucial for the macro panel series where both (*i* and *t*) are large. However, in the case of micro or short panels where number of *i* is greater than *t*, checking the unit root is not mandatory as the short panel does not exhibit the issue of non-stationarity.

Further, the methodologies we chose for the analysis don't demand from us to conduct pre-unit root tests. Therefore, we haven't applied the unit root tests. We used the Variance Inflation Factor (VIF) test in the pre-testing analysis to detect multicollinearity. Results of VIF are available in Table 2. The high value of VIF represents the higher level of correlation between the variables. If the value of VIF attached to a variable is lower than 10, the variable can be included in the model. From Table 2, we can see that the VIF value linked to every variable is lower than 10, indicating the fact that these variables can be included in the model. The mean VIF is 2.83, which is far below the threshold value of 10, also confirming that our model is free of the issue of multicollinearity.

Table 2: VIF results

Variable	VIF	1/VIF
DG	5.52	0.181
GDP	5.07	0.197
DFI	3.14	0.318
HC	2.70	0.370
Trade	1.93	0.518
CO_2	1.67	0.600
FDI	1.39	0.720
NRR	1.20	0.833
Mean VIF	2.83	

Source: Authors' own calculations

The outcomes of 2SLS and system-GMM for the full sample, Asia, America, Europe, and Africa, are provided in Table 3. In total, 10 models are estimated, five with 2SLS and five with system GMM. The results show that *DG* has a favorable impact on *GI* in all samples except Africa. An improvement in *DG* by 1%, the *GI* escalates by 0.226%, 0.397%, 2.455%, 1.718% in the 2SLS models, and 0.134%, 0.231%, 1.241%, 1.524% in the GMM models in the full sample, Asia, America, and Europe. These results are supported by hypothesis 1. This result is backed by Tian *et al*. (2022), who documented that digital government promotes the expansion of green investment. The study result also infers that digital government enables investors to use their available resources to enhance green investment effectively. Digital government creates opportunities for green investment and sustainable development. A similar result is found by Alshubiri (2023). Liao *et al*. (2023) illustrated that the digital government promotes green investment and provides a new path for the development of the green economy. The results also suggest that the digital government efficiently improves the rate of resource utilization, hence raising the level of green investment. The study also reported that digital government contributes significantly to the augmentation of green investment through technology development that improves sustainable development efforts. This result is also in line with Li *et al*. (2023), who noted that countries investing in digital infrastructure experience more effective resource distribution towards green investment. Furthermore, digital governments promote accountability and transparency by enhancing green investment opportunities. The study of Guo *et al*. (2024) supported our results and suggested that digital governments facilitate stakeholder collaboration, fostering investment in innovative green projects.

The estimates attached *DFI* are favourably related to *GI* in the full sample, Asia, America, Europe, and Africa. Quantitively, for every 1% escalation of *DFI*, the *GI* improves by 1.632%, 1.742%, 1.728%, 0.695%, 0.044% in 2SLS models, and 1.023%, 1.214%, 1.126%, 0.424%, 0.029% in GMM models in full sample, Asia, America, Europe, and Africa. These results confirm hypothesis 2. The result is consistent with the research by Jiang *et al*. (2022), who reported that *DFI* provides access to financial services for businesses. This accessibility enables businesses to be involved in green initiatives, contributing to the development of the green investment sector. Similar results are described by Jiang (2023) and noted that *DFI* positively correlates with augmented access to financial services, ultimately raising economic growth and green investment. *DFI* through mobile banking enables users to perform financial transactions through mobile devices. It empowers businesses and individuals engaged in green activities, easing financial transactions and investments in eco-friendly green projects. The finding aligns with Wei *et al*. (2023), who highlighted the positive role of mobile banking in expanding financial inclusion that positively influences investments in sustainable and green projects. This means that *DFI*, through Fintech innovations, offers new opportunities for green investment. These innovations can streamline and facilitate green investment processes. A study done by Lin & Ma (2022) noted that Fintech innovations play a significant role in attracting green investments and offering transparent and efficient solutions for project developers. Moreover, *DFI* contributes to risk mitigation in green investments.

Likewise, in the full sample, Asia, America, Europe, and Africa, we see an improvement in *GI* by 2.186%, 4.848%, 5.061%, 3.061%, 0.077% in 2SLS models and 1.171%, 1.084%, 3.349%, 2.412%, 0.039% in the GMM for every 1% increase in the *GDP*. Further, the estimates of CO_2 are positively significant in Asia, America, and Europe only – due to a 1% rise in CO_2, there is an escalation of *GI* by 0.999%, 1.957%, 0.721%, and 0.689%, 1.411%, 0.614% in the 2SLS and GMM models. The estimated coefficients attached to *FDI* are significantly and favorably linked to *GI* in all models in the full sample as well as European and African regions; however, when we apply the GMM estimator, the estimates of *FDI* are favorably linked to *GI* in the full sample, Asia, America, and Europe. Specifically, the *GI* escalates by 0.075%, 0.418%, 0.007% (2SLS) in the full sample, Europe, and Africa, and 0.022%, 0.047%, 1.533, 0.341%, (GMM) full sample, Asia, America, Europe, respectively. The estimated coefficients of *HC* are positively significant in the full sample, America, and Europe – a 1% improvement in *HC* causes an escalation in *GI* by 1.430–1.008% (full sample), 1.348–1.073% (America), 0.247–0.194% (Europe) in the 2SLS-GMM models. In contrast, we find an inverse relationship between *Trade* and *GI* in the full sample as well as in all regions except Africa – a 1% growth of *Trade* decreases the *GI* by 1.105–1.003% (full sample),1.479–1.124% (Asia), 4.238–2.143% (America), 0.260–0.174% (Europe) in 2SLS-GMM models. In the GMM models, there is an additional regressor, *L.GI*, which is a lag term of the dependent variable. The estimates of *L.GI* are positive and significant, confirming the fact that the *GI* in the previous year induced a positive change in the current year's *GI*. Additionally, the validity of our instruments is confirmed using the Hansen test, with all the statistics are insignificant. The results also suggest that the AR (2) test statistics do not provide sufficient evidence to reject the null hypothesis, indicating no autocorrelation in any of the models.

Table 3: 2SLS & system-GMM results

	Full		Asia		America		Europe		Africa	
	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
L.GI		1.026*** (0.006)		1.045*** (0.009)		0.875*** (0.032)		0.668*** (0.056)		0.635*** (0.075)
DG	0.226*** (0.097)	0.134* (0.076)	0.397** (0.177)	0.231** (0.106)	2.455** (1.118)	1.241*** (0.329)	1.718*** (0.186)	1.524*** (0.130)	0.050 (0.036)	0.039 (0.028)
DFI	1.632*** (0.435)	1.023*** (0.024)	1.742*** (0.448)	1.214*** (0.041)	1.728* (1.004)	1.126** (0.065)	0.695*** (0.217)	0.424*** (0.054)	0.044*** (0.011)	0.029*** (0.011)
GDP	2.186*** (0.597)	1.171*** (0.085)	4.848*** (1.110)	1.084*** (0.165)	5.061** (2.211)	3.349*** (0.314)	3.061*** (0.126)	2.412*** (0.088)	0.077* (0.042)	0.039** (0.019)
CO_2	0.100 (0.327)	0.065 (0.041)	0.999* (0.526)	0.689*** (0.072)	1.957* (1.013)	1.411*** (0.192)	0.721*** (0.146)	0.614*** (0.060)	0.029 (0.022)	0.022 (0.015)
FDI	0.075* (0.041)	0.022*** (0.007)	0.109 (0.109)	0.047*** (0.016)	2.065 (2.621)	1.533*** (0.032)	0.418*** (0.014)	0.341*** (0.005)	0.007** (0.003)	0.005 (0.004)
Trade	−1.105*** (0.260)	−1.003** (0.043)	−1.479** (0.585)	−1.124*** (0.086)	−4.238*** (1.625)	−2.143*** (0.118)	−0.260** (0.127)	−0.174*** (0.065)	0.003 (0.015)	0.023 (0.074)
HC	1.430*** (0.455)	1.008*** (0.085)	0.788 (1.093)	0.211 (0.269)	1.348** (0.641)	1.073*** (0.294)	0.247* (0.133)	0.194* (0.107)	0.023 (0.026)	0.067 (0.051)
NRR	−0.003 (0.012)	−0.008 (0.022)	−0.018 (0.023)	−0.006 (0.035)	−0.104 (0.407)	−0.002 (0.006)	−0.013 (0.014)	−0.006 (0.007)	0.002 (0.007)	0.007 (0.006)
Constant	22.83*** (7.345)	17.65*** (5.141)	34.81*** (9.342)	19.89* (10.07)	9.078*** (2.542)	−7.682** (3.645)	2.217 (1.700)	4.500 (6.728)	5.514*** (0.269)	4.577*** (1.186)
Number	71	71	22	22	14	14	24	24	11	11
Hansen test [*p*-value]		0.553		0.288		0.679		0.486		0.678
AR(2) [*p*-value]		0.231		0.185		0.474		0.375		0.518

Notes: Standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Authors' own calculations

The robustness check is performed with the help of SIVQR results. The outcomes of this method appear in Table 4. Each variable is estimated across nine quantiles, *i.e.* from 0.10 to 0.90. The estimates of our primary regressors *DG* and *DFI* are positively connected to *GI* across all quantiles *i.e.* from 0.10 to 0.90, implying that *DG* and *DFI* are helpful in boosting *GI* at all levels of *GI*. In addition, the analysis controls the factors of *GDP*, CO_2, *FDI*, *HC*, and *NRR*. Out of these control variables, the estimates of *GDP* and CO_2 are significant and positive at all quantiles from 0.10 to 0.90, suggesting that *GDP* and CO_2 boosts *GI* at all of its intensities. However, there is an inverse connection between *Trade* and *NRR* at all levels of *GI*, *i.e.* from 0.10 to 0.90 quantiles, highlighting the negative impact of *Trade* and *NRR* on all magnitudes of *GI*. Further, the estimated coefficients of CO_2 and *FDI* are positive but insignificant.

Table 4: SIVQR results

Variables	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
DG	0.838*** (0.248)	0.383*** (0.117)	0.288** (0.109)	0.619** (0.269)	1.404** (0.644)	1.948** (0.784)	2.163** (1.115)	2.559** (1.234)	3.232*** (1.345)
DFI	1.202*** (0.225)	1.150*** (0.198)	1.008*** (0.145)	0.852** (0.131)	0.789*** (0.108)	0.933*** (0.145)	1.382*** (0.316)	1.513*** (0.574)	1.941*** (0.654)
GDP	0.585*** (0.078)	0.366*** (0.053)	0.226*** (0.037)	0.187*** (0.022)	0.355*** (0.121)	0.551*** (0.151)	1.108*** (0.213)	1.566*** (0.345)	1.965*** (0.452)
CO_2	0.676*** (0.157)	0.286** (0.132)	0.120** (0.049)	0.192*** (0.071)	0.345** (0.175)	0.491* (0.286)	0.696* (0.407)	1.032** (0.507)	1.336** (0.623)
FDI	0.016 (0.034)	0.077 (0.023)	0.015 (0.012)	0.009 (0.021)	0.003 (0.039)	0.017 (0.076)	0.142 (0.109)	0.198 (1.325)	0.248 (1.684)
Trade	−0.782*** (0.034)	−0.125*** (0.023)	−0.151*** (0.017)	−0.162*** (0.029)	−0.190*** (0.064)	−0.318*** (0.094)	−1.125*** (0.112)	−1.328*** (0.216)	−1.276*** (0.325)
HC	0.220 (0.324)	0.039 (0.257)	0.022 (0.078)	0.094 (0.110)	0.182 (0.343)	0.132 (0.545)	0.537 (1.178)	0.739 (1.507)	1.124 (1.645)
NRR	−0.049*** (0.007)	−0.011** (0.005)	−0.013*** (0.002)	−0.021*** (0.003)	−0.032*** (0.009)	−0.042*** (0.014)	−0.065** (0.031)	−0.074* (0.041)	−0.094* (0.049)
Constant	11.19*** (2.034)	10.10*** (1.742)	9.171*** (1.115)	7.418*** (1.006)	4.508*** (0.899)	5.589*** (1.218)	7.520*** (1.758)	8.683*** (1.944)	11.66*** (2.325)
Observations	1,065	1,065	1,065	1,065	1,065	1,065	1,065	1,065	1,065

Notes: Standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Authors' own calculations

6. Conclusion and implications

As the digital economy invades economic society, there is a noteworthy shift in the worldwide economy from being service-oriented to digitally driven. The advancement of digital technology has played a fundamental role in the construction of digital platform infrastructure. The promotion of green investment emerges as a catalyst for social and economic development. The construction of a digital government and financial inclusion services are instrumental in driving green investment. However, no empirical evidence is found on the exploration of the influence of digital government and digital financial inclusion on green investment. To fill this gap, our study examines the impact of digital government and digital financial inclusion on green investment using top polluted economies. This study applies 2SLS, GMM, and instrumental quantile regression using panel data from 2007 to 2021 for analysis. Besides analyzing the top-polluted economies, we've conducted a regional analysis by disaggregating the data. The findings reveal that digital government promotes green investment in all regions except Africa. While digital financial inclusion also has a favorable impact on green investment in the full sample, Asia, America, Europe, and Africa. The control variables of *GDP*, CO_2, *FDI*, and human capital foster green investment in top polluted economies, while trade reduces green investment in these economies.

The findings suggest several policy implications. First of all, governments of top carbon economies should prioritize the enactment and strengthening of policies targeted at encouraging digital financial inclusion, confirming broader access to financial services, and supporting financial literacy initiatives. Simultaneously, investing in the growth of digital platforms devoted to green investment can create user-friendly environments, proposing information on sustainable projects and streamlining green investment processes. To incentivize green investment, policymakers can explore the use of financial subsidies and incentives delivered through digital channels, inspiring businesses and individuals to contribute in eco-friendly projects. Reinforcement of digital governance frameworks becomes fundamental for regulating and monitoring environmental impact, with the integration of IoT to enforce compliance. Collaboration through financial institutions, environmental organizations, and technology companies is essential for leveraging digital platforms for sustainable financing. Moreover, digital skills and capacity-building training programs focused on green finance will empower professionals to use digital tools efficiently for project management and decision-making. Governments should establish robust evaluation and monitoring frameworks to assess the effectiveness of digital initiatives in driving green investments and guiding policy adjustments. Lastly, active participation in international collaborations will enable economies to contribute to a comprehensive approach to sustainable green finance, fostering a collective commitment to economic and environmental goals.

Our study has several limitations, which should be addressed in upcoming research. The first limitation is that the sample includes data for 71 top polluted economies because of the unavailability of data. Future studies can expand the size of sample if data for other polluted economies become available. Another limitation of the study is that it does not account for long-and short-run dynamics of the relationship, which can be reported through the panel autoregressive distributed lag. Moreover, future studies can apply the panel nonlinear autoregressive distributed lag estimation method, which can also capture the impact of positive and negative shocks in digital government and digital financial inclusion on green investment. Lastly, future studies can expand the scope of analysis by incorporating more variables in the model, such as climate risk, access to green finance, stakeholder pressure, and environmental awareness.

Acknowledgement

Conflict of Interest: The authors declare no competing interests.

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Appendix

Table A1: List of sample countries

No.		Country	No.	Regions	Country
1	America	Peru	37	Europe	France
2	America	Guatemala	38	Europe	Greece
3	America	Mexico	39	Europe	Ukraine
4	America	Brazil	40	Europe	Denmark
5	America	Chile	41	Europe	United Kingdom
6	America	Argentina	42	Europe	Lithuania
7	America	Venezuela	43	Europe	Portugal
8	America	Bolivia	44	Europe	Austria
9	America	Honduras	45	Europe	Poland
10	America	Colombia	46	Europe	Switzerland
11	America	Ecuador	47	Europe	Slovenia
12	America	United States	48	Europe	Serbia
13	America	Canada	49	Europe	Netherlands
14	America	Panama	50	Europe	Bulgaria
15	Asia	Nepal	51	Europe	Belgium
16	Asia	Thailand	52	Europe	Sweden
17	Asia	India	53	Europe	Estonia
18	Asia	Lebanon	54	Europe	Croatia
19	Asia	Israel	55	Europe	Germany
20	Asia	Cambodia	56	Europe	Hungary
21	Asia	China	57	Europe	Czechia
22	Asia	Indonesia	58	Europe	Romania
23	Asia	Philippines	59	Europe	Finland
24	Asia	Singapore	60	Europe	Spain
25	Asia	Pakistan	61	Africa	Senegal
26	Asia	Sri Lanka	62	Africa	Morocco
27	Asia	Azerbaijan	63	Africa	Nigeria
28	Asia	Uzbekistan	64	Africa	Angola
29	Asia	Jordan	65	Africa	South Africa
30	Asia	Kazakhstan	66	Africa	Kenya
31	Asia	Bangladesh	67	Africa	Algeria
32	Asia	Iran	68	Africa	Cameroon
33	Asia	Malaysia	69	Africa	Ghana
34	Asia	Japan	70	Africa	Egypt
35	Asia	Turkey	71	Africa	Tunisia
36	Asia	Kyrgyzstan			

Source: Authors' own elaboration