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THE ROLE OF DIGITAL ECONOMY AND SOCIETY IN PROMOTING GREEN ACCOUNTING FINANCE: FRESH INSIGHTS FROM NEW ESTIMATION

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ABSTRACT

Objectives of the Study: This study attempts to empirically investigate the connections of digital society and economy (DESI) on green accounting finance (GAF) by applying diverse econometric methods to a global sample of 24 nations during the 2010 - 2022 stage.

Methodology: Four e-commerce measures are used to evaluate digital enterprises: online sales, electronic commerce sales, electronic trade web sales, and electronic commerce turnover. Additionally, two aspects of e-business are evaluated: CRM and cloud services. Various econometric techniques are used to support our conclusions, including modeling with PCSE and FGLS estimation. These methods work well with data with a cross-sectional dependency and may present certain econometric challenges, such as heteroskedasticity, endogeneity, and multicollinearity. Economists and decision-makers can choose a suitable strategic path for sustainable development by promoting digitalization and green accounting finance with the aid of this paper's results.

Result: The estimation results demonstrate that digital transformation into society and economy promotes green accounting finance. We obtain solid results by employing more explanatory variables and utilizing various econometric approaches. The conclusion is that these activities help enhance green finance.

Conclusion: Our findings indicate that the promotion of digitization is essential for the successful implementation of green accounting financing initiatives across European countries.

Keywords: *digitl economy and society, green accounting financing, European countries*

1. INTRODUCTION

The financial services industry may undergo a significant transition as a consequence of the numerous economic ramifications of global warming (Awosusi et al., 2024; Bopp, 2020; Schandl et al., 2024)which could have a significant impact on the nation's biocapacity and ecological footprint. As a result, this study examined the environmental impact of resource efficiency, biomass energy, and economic growth in Malaysia, within the load capacity curve hypothesis framework, while controlling economic globalization, financial globalization and trade globalization. This research utilizes the ARDL estimator and the bootstrapped time-varying causality

(TVC. Among many other matters that are crucial to the financial sector, this phenomenon is, in fact, at the top of the company's schedule. At least three important variables need to be considered when examining the relationship between the economic industry and "sustainable development (SD)" (Lenzen et al., 2022; Pata & Karlilar, 2024). Initially, it was thought that the finance industry indirectly influenced green growth by influencing the environmental and sustainability elements of its customers, such as projects, borrowers, and investees (Thompson, 2022; Thompson & Cowton, 2004; Weber, 2014; Weber et al., 2010; Srdelić, 2024). Since having a connection to capital is typically a need for achievement in the company, it is clear that the indirect effects of finance are significant. Then according to Weber et al. (2010), there are numerous ways in which environmental rules have impacted and continue to impact the financial industry. Environmental legislation concerning air, water, and soil contamination, for instance, had an impact on how credit risk was handled in the 1990s when it came to managing dangers to the environment (Boyer & Laffont, 1997). According to Richardson (2009)the current approach largely confines the financial sector to a transactional agent to mobilise capital for clean energy and to broker emission allowance trading. The sector's potential to leverage more sweeping positive changes in the economy as sought historically through the movement for socially responsible investment (SRI, financial institutions must effectively handle all of the chances and hazards that come with long-term viability, such as mitigating poverty and global warming. The possibilities have grown over time. However, it is important to acknowledge that the finance industry has frequently adopted a reactive approach towards sustainability concerns as opposed to a proactive one. Thirdly, the financial results and social hazards faced by financial firms are impacted by stress from stakeholders who prioritize sustainable development (Evangelinos & Nikolaou, 2009; T. T. H. Le & Thi Hang Phan, 2024; Scholtens & Zhou, 2008).

Financial service suppliers typically focus on business-to-consumer (B2C) retail enterprises offering four primary goods categories: payment, finance, investment, and insurance. These product categories are further divided into two major subsectors: finance and insurance. In the first case, capital is provided, savings are accumulated, and risks are transferred; in the latter case, risks are largely transferred and managed. It is challenging to distinguish between financial offerings and other goods because, from a traditional standpoint, they are the least fascinating. However, consumer orientation is now a crucial component of the competition due to digitization (Bons et al., 2012; Garzaro et al., 2020). Competitive firms that have recently adopted digital technology present themselves with a range of standardized and user-friendly digital goods. Customers' ability to choose between services from established and emerging financial services firms for their loans, investments, insurance, mortgages, and accounts will be enhanced by a reduction in switching costs. This will call into question their previous solid, dependable relationship with these providers (Dehnert, 2020; Pousttchi & Dehnert, 2018; Uribe-Linares et al., 2023).

Numerous scholars in the handling field have examined the obstacles that industry leaders encounter when attempting to innovate their enterprises (Eklund & Kapoor, 2019). Specifically, a major revolution is occurring in the fiscal services sector. In the age of digital technology, the once-stable industry exhibits remarkable competitive dynamism, modifications to regulations, and non/near-banks as asymmetric challengers. Practitioners discuss an unexpected development that has the potential to diminish the importance of traditional vendors of financial services. Dehnert (2020), who concentrated on upcoming industry prospects in relation to profitability indicators, provided a current example of this. Three factors were considered in the research conducted by Chiorazzo et al. (2018): actual locations, substantial market power, and sources of income from traditional offerings. The study focused on the digital transformation of established financial service firms. In order for society to thrive sustainably, insurance companies and established banks play important responsibilities. Given that there are many important

economic activities, such as promoting wealth-saving development and supplying credit to the economy, accounts for its relevance.

As far as we know, this is the first research study exploring the relationship between digitization and green accounting finance. Another advantage of this article is its methodology, which uses a variety of indicators to identify two critical elements—digitalization and green accounting finance to provide a thorough analysis of their interaction. Four e-commerce measures are used to evaluate digital enterprises: online sales, electronic commerce sales, electronic trade web sales, and electronic commerce turnover. Additionally, two aspects of e-business are evaluated: CRM and cloud services. Various econometric techniques are used to support our conclusions, including modeling with PCSE and FGLS estimation. These methods work well with data with a cross-sectional dependency and may present certain econometric challenges, such as heteroskedasticity, endogeneity, and multicollinearity. Economists and decision-makers can choose a suitable strategic path for sustainable development by promoting digitalization and green accounting finance with the aid of this paper's results.

This is how the remain of the paper is created. While we discuss the model, data, and prediction process in Section 3, we evaluate pertinent literature in Section 2. In Section 4, we represent our empirical outcomes. In Section 5, we bring the paper to a close.

2. LITERATURE REVIEW

2. 1. CONCEPTUAL FRAMEWORK OF THE DIGITAL ECONOMY AND GREEN ACCOUNTING FINANCE

The digital economy is being widely acknowledged as the new engine of economic expansion, representing a rapidly emerging economic paradigm. DE restores the value of things to its subjective core by focusing on individual utility. Researchers from all around the world have been examining how the advancement of information technology has affected society since the late 1990s. From a policy research standpoint, Rai et al. first suggested a technique for calculating the index of social informatization. At the moment, researchers are still concentrating on index measurements of the digital economy, honing many characteristics in order to create a complete framework. Liu et al., for example, contend that the industrial structure is impacted by DE. They design an extensive indexing scheme for the growth of DE by three dimensions: industrial digitalization, digital industrialization, and digital infrastructure. They evaluate China's degree of digital economy progress using quantitative indicators and the time-series worldwide principal element analysis structure. Some scholars suggest that a one-dimensional digital economy system promotes economic growth and go into great depth about it. They contend that by encouraging industrial digitization and information industrialization and so vertically extending the capital production structure, the implementation of digital data components strengthens the structure of capital production.

Although there is not a single accepted concept for green accounting finance as a fresh fiscal paradigm, the research that is now available outlines three main ideas. First of all, it includes ecological finance, which offers fiscal services to solve real-world problems related to pollution mitigation, resource conservation, environmental preservation, and other green efforts (Dong & Tao, 2022; Gray, 2002). Next, it is thought of as a type of financial innovation that makes use of different financial goods and mechanisms. According to the third and most recent viewpoint, it is a financial model that uses green-oriented insurance, credit, investment, securities, and carbon finance to promote environmentally conscious investment and eco-conscious society. Research on GAF is changing with a focus on conceptual understanding and qualitative analysis in light of these conflicting conceptualizations. Research indicates that green credit policies

can improve the effectiveness of financial resource allocation by shifting capital from sectors characterized by high energy consumption and pollution to those that protect the environment, therefore improving the quality of the environment. It also shows how important it is to invest in environmental governance and green financial capital in order to lessen the effects of environmental degradation. There is still a dearth of quantitative research on the evolution of green accounting finance, notwithstanding this qualitative investigation. Previous studies have primarily used individual metrics to measure the development of GAF, such as the rate at which flows of low-carbon finance advance and the amount of green investments and credit that are made.

Although certain conceptual indicators can shed light on how green accounting finance is evolving, they frequently do not provide a complete picture. In order to overcome these constraints, researchers have developed assessment frameworks that allow for a thorough assessment of the state of green financial growth. A system of index has been developed to evaluate A country's green accounting finance development in five areas: investment, securities, insurance, green credit, and carbon finance. This system is built upon the composite system of green accounting finance development. The link between GAF and high-quality regional development has gained more attention since the creation of the green accounting finance index system. International academics also stress the significance of business and social involvement in raising awareness of green accounting finance. According to Salzmann (2013), Sisodia & Maheshwari (2023), and Songini et al. (2023)social responsibility and green management principles highlight the vital connection between capital demand and supply, financial markets, and financial intermediaries in the context of the financial market-based framework of GAF. In a similar vein, Labatt & White (2003) see green accounting finance as a financial tool based on the market that aims to reduce environmental risks and enhance environmental quality. To aid in the nation's shift to a greener economy, scholars support the creation of a country's green financial system. According to Peng et al. (2018), Pating (2022), and Wang & Yun (2013), a country could create a green accounting finance system that would ease financial strains brought on by environmental concerns, create new growth opportunities, improve the potential for economic growth, hasten the green transformation of the country's energy, transportation, and industrial structures, and increase the country's technological content. In order to achieve high-quality economic development, Chen et al. (2024), Du et al. (2023), Nurgaliuly & Smagulova (2025), and Liu & He (2021) contend that green credit is an essential financial strategy. They also support the use of more market-oriented economic strategies to regulate environmental damage. In addition, Fan et al. (2023), Quan & Quan (2023), and Wu et al. (2023) argue that financial assistance plays a crucial role in the advancement of GAF by supplying capital support, improving the effectiveness of company transformation, allocating resources optimally, and stimulating technological innovation. Liu & Li (2024), Lv et al. (2021), and Zhang et al. (2023) argue for the creation of an external institutional environment that is favorable to regional green accounting finance development in order to strengthen the analysis, identification, and handling of ecological risks, improve visibility of enterprise transformation risks, and promote GAF at different levels based on environmental impacts. Scholars emphasize the significance of strengthening risk and crisis detection capabilities and incorporating market supervision into a country's financial system in order to create a green financial system.

2. 2. DIGITAL ECONOMY AND GREEN ACCOUNTING FINANCE'S EFFICIENCY

Investigating the relationship between environmental legislation, DE, and GAF, as well as how they affect green technology innovation, is essential for aspiring scholars. These kinds of research can encourage businesses to innovate in technology and promote the growth of the green

economy. For instance, Grossman et al. found that the links show an inverted "U" shape similar to the Kuznets curve when examining the connection between financial development and certain environmental pollutant outputs. Chinese academics support the utilization of scientific and technological tools to foster effective economic growth and are aware of the importance of green development for the economy. He suggests that improvements in economic efficiency, green development, and social welfare are the main drivers of a country's improved economic development quality. According to Wang & Zhang (2022), Wang et al. (2022), Xie et al. (2023), Idris & Rahman Razak (2025) and Yang et al. (2022), environmental restrictions can greatly improve the quality of economic growth from a Chinese point of view. However, technical innovation is necessary to achieve high-quality economic development. In order for businesses or industries to handle the combined pressures of market demands and governmental regulations, they must uphold the principles of ecological laws and utilize digital economy technologies to reach green upgrading, especially within the context of the new development concept.

The ongoing progress of the digital economy has attracted substantial interest. High-quality economic development depends on both DE and GAF, but little is known about how they are related. A green economy can function more effectively if customers are empowered by the digital economy to allocate their renewable energy and make efficient use of scarce resources. According to An et al. (2024), Ma et al. (2024), and Xiao et al. (2023), the convergence of green and digital economies may open up new avenues for economic recovery and sustainable development. Yin & Xu (2022), Zhang & Zhao (2023), and Zhong et al. (2023, 2024) contend that there is an intimate correlation between GAF and DE as two important economic paradigms of the future. According to Wang et al. (2022), Xiao et al. (2023), Xin et al. (2023), and Xiufan et al. (2024)the spatial dynamic Durbin model is applied to exploit the influence of energy internet (EI, the IoTs, as the embodiment of the digital economy, have the ability to propel the creation of a green economy and provide fresh growth momentum for a country's economic progress. A digital economy and a green economy are mutually dependent, as An et al. (2024), Hwang (2023), and Sun et al. (2024)green innovation, and the level of sustainable development. Panel data from 268 cities in Chin point out, and they both call for coordinated efforts. A country's economic potential cannot be completely fulfilled unless green and digital growth work together harmoniously. Because of this, academics are becoming more and more interested in examining how the digital economy affects the development of green accounting finance, realizing that this industry has enormous potential for future expansion.

Numerous academics have recognized the possibility that the digital economy could ease the shift to more environmentally friendly business practices. Quantitative research has not been done enough, nevertheless, to establish the exact nature of the correlation between the digital economy and economic investment and whether it really has an impact on the growth of GAF. Moreover, the importance of this paper's research is highlighted by the dearth of publications that specifically examine the connection between DE and GAF. The target of this study is to examine if the growth and method of the digital economy can actually and significantly enhance the effectiveness of sustainable finance investment and development.

3. RESEARCH METHODOLOGY

The model utilised to examine the link of digital economy and society (DIGI) and *green accounting finance* (GAF) could be represented as follows:

$$GAF_{it} = \beta_0 + \beta_1 DIGI_{i,t} + \beta_2 INC_{i,t} + \beta_3 EXP_{i,t} + \beta_4 GE_{i,t} + \beta_5 IND_{i,t} + \beta_6 CE\_MW_{i,t} + \beta_7 EI\_ISO_{i,t} + \beta_8 NR_{i,t} + \beta_9 SAV_{i,t} + \beta_{10} INFL_{i,t} + \beta_{11} POP_{i,t} + \varphi_t + \omega_i + \varepsilon_{ijt} \quad (1)$$

where i and t respectively represent country i and year t. φ_t and ω_i are added into the model to

capture the country and year-fixed effects and ε_{ijt} is the error term.

Measures of accounting finance (GAF):

In this article, green accounting finance is measured Material flows and resource productivity indicators are central to monitoring the changing patterns of resource use as global economies grow (ton). This variable was sourced from UNEP IRP Global Material Flows Database. All variables are taken annually from 2015 to 2022.

Key independent variable:

Following Ha (2022a, 2022b), Ha & Thanh (2022), and Myovella et al. (2020), the primary target of this paper was to determine the link between digitisation and GAF. is the primary explanatory variable, encomprising the composite index and the nine aspects showing the procedure of digital transition, encomprising Internet user skills (*desi_hc_bsu*), digital technologies for businesses (*desi_idt_dtb*), e-Commerce (*desi_idt_ecomm*), e-Commerce's turnover (*desi_idt_ecomturn*), electronic information sharing (*desi_idt_eis*), big data (*desi_idt_bigdat*), cloud (*desi_idt_cloud*), artificial intelligence (*desi_idt_ai*), and SMEs selling online (*desi_idt_smeso*). More specifically, *desi_hc_bsu* is a variable that represents People who possess "basic" or "above basic" digital abilities in each of these five areas: safety, problem-solving skills, digital content creation, communication and cooperation, information and data literacy. *Desi_idt_dtb* is the percentage of SMEs using digital technologies. *Desi_idt_ecomm* measures the number of SMEs that use e-commerce. *Desi_idt_ecomturn* shows data on SMEs' total turnover from e-commerce. *Desi_idt_eis* represents enterprises that have utilised an ERP (enterprise resource planning) software package to share data between various functional areas (e.g., accounting, planning, production, marketing). Moreover, *desi_idt_bigdat* indicates enterprises analysing big data from any data source. *Desi_idt_cloud* demonstrates businesses that purchase no less than one of the following online computing services: processing power, accounting software, CRM software, and database hosting. *Desi_idt_ai* refers to enterprises that use AI technology. Finally, *desi_idt_smeso* shows SMEs selling online (at least 1% of turnover). Digitalization data are gathered from different surveys, like Eurostat's survey on the use of IT in households and individuals, Eurostat's survey on ICT Enterprises, and Government e-reports. During the years 2015–2022, these surveys were carried out on 27 European Union members, including the United Kingdom. These metrics are anticipated to show how well European nations' digital transformations are going.

Control variables:

The selection of the explanatory factors is predicated on empirical research found in published works. Economic growth (INC), trade share (EXP), industrialization level (IND), and degree of democratization (GE) are the explanatory variables used here. Our theoretical structure also considered the number of firms with ISO1001 (*EI_ISO*) and circularity performance (*CE_MW*) as in Bu, Li, and Jiang (2019), Shahbaz, Nasir, and Roubaud (2018), and Sun et al. (2019). Some variables are also utilised: Population (*POP*), Saving (*SAV*), Inflation (*INFL*), and Natural rents (*NR*). Table 2 presents a correlation matrix for all the variables, and it indicated that circularity and digitalisation are unadversely correlated.

A cross-sectional dependency (CD) test is conducted as follows. We verify the presence of CD in the data using the indicated cross-sectional dependency tests from Pesaran (2021). The unit root tests developed by Levin et al. (2012) are then used to assess the linearity of the included variables with the presence of CD. The results are summarized in Table 3, which shows that although some level indicators are not fixed, they become stationary when the first level of difference is considered. In accordance with Beck & Katz (1995), Ha (2022a, 2022b), Ha & Thanh

(2022), and Le & Bach (2022), we employ the panel-corrected standard error (PCSE) approach to examine the digitalization-circularity linkage for the data with the existence of CD and stationarity of the first-difference variables. To mitigate the possibility of endogeneity arising from the simultaneous relationships between digitalisation and circularity, Equation 1 indicates that each explanatory variable is one period behind. To solve the possible problem of heterogeneity and endogeneity in Equation 1, we additionally recreate our results using several statistical frameworks, like the FGLS and the two-step system GMM, as discussed by Gala et al. (2018), Ha & Thanh (2022), and Sweet & Maggio (2015). Additionally, the cointegration test results in Table 4 affirm the existence of cointegration, suggesting that considering both short-run and long-run dynamics is appropriate.

Table 1. Description of variables

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
GAF	Creditor reporting system	Material flows and resource productivity indicators are central to monitoring the changing patterns of resource use as global economies grow (ton)	UNEP IRP Global Material Flows Database	138	130.41	286.80	0.00	1437.55
DESI	Digital economy and society index	DESI total index, which is determined by averaging the four primary DESI dimensions.	DESI (2023)	144	42.41	10.79	19.40	69.60
DESI_CONN	Connectivity	The weighted average of fixed broadband take-up, fixed broadband coverage, mobile broadband, and broadband price index.	DESI (2023)	144	9.53	3.18	3.17	19.27
DESI_DPS	Digital Public Services	The e-Government score.	DESI (2023)	144	14.23	4.27	1.85	22.79
DESI_HC	Digital human capital	The average of advanced talents and development and internet user skills.	DESI (2023)	144	11.37	2.45	6.87	17.85
DESI_IDT	Integration of digital technology	Encompassing cloud computing, social media, big data, and electronic information exchange.	DESI (2023)	144	7.29	2.68	2.53	14.77
desi_hc_bsu	Internet user skills	People who possess “basic” or “above basic” digital abilities in each of those five areas: safety, problem-solving, multimedia creation, communication and cooperation, data and information literacy.	DESI (2023)	144	25.21	6.50	10.46	39.26
desi_idt_dtb	Digital technologies for businesses	SMEs using digital technologies	DESI (2023)	144	19.49	6.65	8.88	41.37
desi_idt_ecomm	e-Commerce	SMEs with e-commerce	DESI (2023)	144	5.22	2.12	1.33	11.51
desi_idt_ecomturn	e-Commerce’s turnover	SMEs’ total turnover from e-commerce	DESI (2023)	144	11.32	5.32	1.71	29.28
desi_idt_eis	Electronic information sharing	Businesses that have shared data throughout several functional areas (such as accounting, planning, production, and marketing) through the usage of an ERP (company resource management) software package.	DESI (2023)	144	5.79	1.64	2.39	9.54
desi_idt_bigdat	Big data	Companies analysing big data from any data source.	DESI (2023)	144	3.30	1.43	1.36	7.28

Variable	Definition	Measure	Source	Obs	Mean	SD	Min	Max
desi_idt_cloud	Cloud	Companies buying no less than one of those cloud computing services: hosting of the enterprise's database, accounting software applications, CRM software, computing power	DESI (2023)	144	6.00	3.63	1.01	18.45
desi_idt_ai	Artificial intelligence	Enterprises using any AI technology	DESI (2023)	144	1.80	1.24	0.16	6.37
desi_idt_smeso	SMEs selling online	SMEs selling online (at least 1% of turnover)	DESI (2023)	144	12.05	5.10	3.46	25.11
INC	Economic growth	The real GDP per capita (constant 2010 US dollars).	WDI	144	10.19	0.64	8.94	11.59
EXP	Trade share	The proportion of GDP.	WDI	144	9.73	0.88	8.46	12.32
GE	Level of democratization	The index of democratization	FSSDA	144	1.03	0.59	-0.33	2.05
IND	Industrialization level	The value added to GDP.	WDI	144	10.92	0.77	9.49	12.65
CE_MW	Circularity performance		WDI	120	0.45	0.54	0.00	3.06
EI_ISO	ISO 14001 certificates	The number of firms with ISO1001	OECD.Stat	96	25.04	6.45	7.34	49.13
NR	Natural rents	Share of the sum of coal rents, mineral rents, natural gas rents, and forest rents to GDP (%).	WDI	144	3.38	4.00	-1.25	19.71
SAV	Saving	Annual saving to total GDP (%).	WDI	96	4.57	0.81	2.90	6.25
INFL	Inflation	Annual growth of CPI inflation (%).	WDI	144	3.38	4.00	-1.25	19.71
POP	Population	Total of population.	WDI	96	4.57	0.81	2.90	6.25

Note: 1* is Global Facility For Disaster Reduction And Recovery & WorldPop Gridded Population Data. 2* stands for Joint Research Center & WorldPop Gridded Population Data. 3* stands for United Nations Environmental Program & WorldPop Gridded Population Data. 4* stands for Institute for International Law of Peace and Armed Conflict & WorldPop Gridded Population Data and 5* stands for Center For Remote Sensing Of Ice Sheets & WorldPop Gridded Population Data.

Source: Author's calculations.

Table 2. Correlation coefficients

	GAF	DESI	DESI_ CONN	DESI_ DPS	DESI_HC	DESI_ IDT	desi_hc_ bsu	desi_idt_ dtb	desi_idt_ ecomm	desi_idt_ ecomturn	desi_idt_ eis	desi_idt_ bigdat	desi_idt_ cloud	desi_ idt_ai	desi_idt_ smeso
GAF	1														
DESI	0.0125	1				1									
DESI_ CONN	-0.0618	0.746***	1												
DESI_ DPS	0.0477	0.923***	0.575***	1											
DESI_HC	0.0631	0.838***	0.370***	0.748***	1										
DESI_ IDT	-0.00979	0.901***	0.562***	0.754***	0.824***	1									
desi_hc_ bsu	0.169*	0.756***	0.283***	0.679***	0.937***	0.764***	1								
desi_idt_ dtb	0.0119	0.880***	0.586***	0.717***	0.786***	0.978***	0.726***	1							
desi_idt_ ecomm	-0.100	0.632***	0.262**	0.560***	0.650***	0.742***	0.610***	0.600***	1						
desi_idt_ ecomturn	-0.0782	0.593***	0.234**	0.531***	0.637***	0.679***	0.596***	0.544***	0.941***	1					
desi_idt_ eis	0.280***	0.477***	0.198*	0.430***	0.407***	0.623***	0.485***	0.637***	0.400***	0.303***	1				
desi_idt_ bigdat	0.0513	0.599***	0.326***	0.443***	0.664***	0.709***	0.635***	0.710***	0.538***	0.494***	0.556***	1			
desi_idt_ cloud	-0.131	0.863***	0.648***	0.709***	0.727***	0.907***	0.635***	0.902***	0.584***	0.547***	0.387***	0.576***	1		
desi_ idt_ai	0.0113	0.674***	0.458***	0.513***	0.633***	0.771***	0.602***	0.788***	0.491***	0.442***	0.558***	0.573***	0.610***	1	
desi_idt_ smeso	-0.0695	0.652***	0.336***	0.549***	0.659***	0.744***	0.598***	0.610***	0.943***	0.842***	0.407***	0.496***	0.589***	0.541***	1
INC	0.172*	0.672***	0.281***	0.559***	0.769***	0.772***	0.739***	0.704***	0.691***	0.667***	0.505***	0.687***	0.628***	0.619***	0.661***
EXP	-0.147	0.613***	0.239**	0.566***	0.669***	0.665***	0.616***	0.555***	0.804***	0.775***	0.299***	0.617***	0.566***	0.439***	0.699***
GE	0.0854	0.759***	0.287***	0.744***	0.843***	0.755***	0.807***	0.692***	0.657***	0.626***	0.522***	0.612***	0.605***	0.682***	0.642***
IND	0.0227	0.391***	0.170*	0.413***	0.396***	0.349***	0.341***	0.270**	0.419***	0.409***	0.118	0.133	0.271**	0.195*	0.405***
CE_MW	0.0903	0.489***	0.235**	0.423***	0.505***	0.552***	0.507***	0.524***	0.459***	0.417***	0.462***	0.448***	0.386***	0.736***	0.485***
EI_ISO	-0.172*	0.00492	-0.0373	0.0622	0.0165	-0.0492	-0.0446	-0.0780	0.0305	0.0761	-0.340***	-0.374***	0.123	-0.323***	0.0315

	INC	EXP	GE	IND	CE_MW	EI_ISO
INC	1					
EXP	0.822***	1				
GE	0.820***	0.720***	1			
IND	0.506***	0.501***	0.489***	1		
CE_MW	0.647***	0.468***	0.629***	0.380***	1	
EI_ISO	-0.283***	-0.124	-0.170*	0.0219	-0.236**	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's calculations

Table 3. Cross-sectional dependence tests and stationary tests

Variable (in level)	CD-test, Pesaran (2004)	Im-Pesaran-Shin test (Z-bar)	Variable (in difference)	Im-Pesaran-Shin test (Z-bar)
GAF	18.22***	-9.32***	DGAF	-11.47***
DESI	11.22***	-5.91***	DDESI	-11.67***
DESI_CONN	4.30***	-7.32***	DDESI_CONN	-14.25***
DESI_DPS	9.22***	-4.12***	DDESI_DPS	-4.51***
DESI_HC	8.13***	-6.46***	DDESI_HC	-3.51***
DESI_IDT	4.36***	-7.31***	DDESI_IDT	-4.29***
INC	42.070***	3.007	DINC	-3.698***
EXP	8.64***	-12.21***	DEXP	-16.43***
GE	3.54***	-14.21***	DGE	-17.15***
FDI	8.30***	-7.32***	DFDI	-15.43***
IND	12.64***	-12.21***	DIND	-16.93***
CE_MW	8.40***	-7.32***	DCE_MW	-17.93***
EI_ISO	3.10***	-5.32***	DEI_ISO	-15.93***

Note: About the CD test, the null theory is that the cross-section is not dependent. P-value is close to zero, showing that data are correlated across panel groups. Concerning the Im-Pesaran-Shin test, the null theory is "All panels contain a unit root," and the alternative theory is "At least one panel is stationary".

***, **, * are significant levels at 1%, 5%, and 10%, in turn.

Source: Author's calculations

Table 4. Cointegration test

Model: f(DIGI and GAF)	Kao test	Pedroni test	Westerlund test
	Dickey-Fuller test	Phillips-Perron test	Variance ratio
DESI	-3.11***	-2.51***	5.26***
DESI_CONN	-4.17***	-2.56***	5.11***
DESI_DPS	-5.18***	-2.64***	5.24***
DESI_HC	-3.12**	-3.77***	6.34***
DESI_IDT	-3.26***	-2.46***	6.21***

Note: Concerning the Kao test, the null theory is "No cointegration," while the alternative theory is "All panels are cointegrated.". About the Pedroni test, the null theory is "No cointegration,", while the alternative theory is "All panels are cointegrated".About the Westerlund test, the null theory is "No cointegration," while the alternative theory is "Some panels are cointegrated".

Source: Author's calculations

4. EMPRICAL RESULTS

4. 1. DIGITAL ECONOMY AND SOCIETY AND GAF

Table 5 depicts the impacts of DESI overall index and each dimension of DESI on green accounting finance using the PCSE method (Panel A) and the FGLS method (Panel B). According to the PCSE method, the DESI overall index, Digital Public Services, and Integration of digital technology significantly affect green accounting finance. However, the FGLS's result only recognizes the positive influence of Digital Public Services on green accounting finance at a 1% significance level. Notably, when we added more control variables to the PCSE method, the estimated coefficients for the influence of the DESI total index on the above links were higher and statistically significant at a 5% significance level. These outcomes indicate that promoting digital transformation in the socio-economy is the driving force to raise the perfomance of

public investment in the field of green energy. Furthermore, the impact of DESI, as well as its aspects on green accounting finance, can be clarified and amplified when more control variables are taken into consideration.

Examining the impacts of some control variables, a rise in real GDP per capita can enhance all the nexuses at a 1% significance level. This shows that pursuing economic growth can be an effective way to digitalize the economy and society as well as boost green accounting finance. Besides, trade share significantly negatively impacts all relationships related to green accounting finance. Similarly, the results related to the CE_MW and EI_ISO are different, depending on which methods we used. To be more specific, the PCSE method indicates that both CE_MW and EI_ISO have a statistically negative influence on the relationship between DESI (and its dimensions) and green accounting finance, with the exception of the effect of EI_ISO on the integration of digital technology - green accounting finance correlation in normal PCSE method. However, when it comes to the FGLS method, the results show that those two variables do not affect those relationships at any traditional significance level. In addition, we find inconsistent effects of the level of industrialization on the link between DESI (and its dimensions) and green accounting finance.

Table 5. The linear effects of digital economy and society on green accounting finance: Benchmark models

Panel A

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PCSE					PCSE with more variables				
VARIABLES	DESI	DESI_CONN	DESI_DPS	DESI_HC	DESI_IDT	DESI	DESI_CONN	DESI_DPS	DESI_HC	DESI_IDT
L.DESI	0.11*	0.04	0.35***	0.01	0.34**	0.27***	0.10	0.64***	0.13	0.44**
	(0.058)	(0.102)	(0.110)	(0.111)	(0.164)	(0.052)	(0.110)	(0.082)	(0.172)	(0.176)
L.INC	3.88***	4.11***	4.76***	4.11***	4.89***	4.36***	4.76***	6.02***	4.64***	5.46***
	(0.963)	(1.028)	(1.227)	(1.026)	(1.292)	(0.535)	(0.537)	(0.632)	(0.595)	(0.594)
L.EXP	-3.19***	-3.16***	-3.37***	-3.17***	-3.15***	-5.83***	-5.63***	-6.28***	-5.76***	-5.34***
	(0.732)	(0.697)	(0.794)	(0.705)	(0.669)	(0.515)	(0.496)	(0.513)	(0.593)	(0.524)
L.GE	-1.29	0.22	-2.08***	0.33	0.95***	-1.62**	1.54***	-2.24***	1.43**	2.60***
	(0.866)	(0.359)	(0.803)	(0.256)	(0.342)	(0.739)	(0.411)	(0.554)	(0.584)	(0.815)
L.IND	0.14	0.04	0.00	0.03	-0.16	-0.07	-0.26	-0.25	-0.24	-0.43*
	(0.301)	(0.293)	(0.306)	(0.299)	(0.342)	(0.221)	(0.205)	(0.213)	(0.201)	(0.257)
L.CE_MW	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
L.EI_ISO	-0.01***	-0.00**	-0.01***	-0.00*	-0.00	-0.01***	-0.00	-0.01***	-0.00	0.00
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
L.NR						-1.72***	-1.71***	-1.93***	-1.67***	-1.82***
						(0.384)	(0.379)	(0.462)	(0.376)	(0.432)
L.SAV						0.14***	0.16***	0.14***	0.16***	0.13***
						(0.035)	(0.036)	(0.033)	(0.044)	(0.033)
L.INFL						0.04	-0.08	0.12	0.03	-0.13
						(0.136)	(0.184)	(0.207)	(0.208)	(0.170)
L.POP						0.92***	0.59*	0.99***	0.66**	0.58*
						(0.319)	(0.304)	(0.324)	(0.299)	(0.294)
Observations	115	115	115	115	115	92	92	92	92	92
Number of nations	23	23	23	23	23	23	23	23	23	23

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Panel B

	(11)	(12)	(13)	(14)	(15)
	FGLS				
VARIABLES	DESI	DESI_ CONN	DESI_DPS	DESI_HC	DESI_IDT
L.DESI	0.11	0.04	0.35***	0.01	0.34
	(0.071)	(0.140)	(0.108)	(0.201)	(0.219)
L.INC	3.88***	4.11***	4.76***	4.11***	4.89***
	(0.896)	(0.896)	(0.883)	(0.962)	(1.023)
L.EXP	-3.19***	-3.16***	-3.37***	-3.17***	-3.15***
	(0.544)	(0.551)	(0.531)	(0.552)	(0.545)
L.GE	-1.29	0.22	-2.08**	0.33	0.95
	(1.208)	(0.764)	(0.994)	(0.899)	(0.792)
L.IND	0.14	0.04	0.00	0.03	-0.16
	(0.368)	(0.367)	(0.351)	(0.370)	(0.381)
L.CE_MW	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
L.EI_ISO	-0.01	-0.00	-0.01*	-0.00	-0.00
	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
Observations	115	115	115	115	115
Number of nations	23	23	23	23	23
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					

Source: Author's calculations

4. 2. ROBUSTNESS CHECKS

4. 2. 1. THE SHORT-RUN AND LONG-RUN INFLUENCE OF DIGITALIZATION

We also investigate the short- and long-term influences of digitalization on the relationship between DESI overall index (and its aspects) and green accounting finance. For that purpose, we utilized the DFE_ARDL framework in this part. Detailed outcomes are described in Table 7. Concerning long-run impact, the results show that digitalization (*DIGI*) has a negative effect on the link between each dimension of DESI and green accounting finance at a 5% significance level. This implies that promoting digitalization can harm the nexus between the digital economy/society and sustainable finance in the long term. But in terms of the short-term impact, the influence of digitalization on those relationships is insignificant. It is also essential to examine the speed of adjustment to the long-run equilibrium, represented by the value of the EC term. More precisely, the DESI-GAF model's EC term is calculated as −0.26, meaning that 26% of the instability brought about by a temporary shock will be modified back to an equilibrium over the long term (i.e., the adjustment rate is 26% each year). To put it another way, reaching the long-run equilibrium takes an average of four years. Comparably, the average period of adjustment to the long-run equilibrium is roughly 7, 2.3, 7.7, and 7 years, respectively, according to the EC terms of the DESI_CONN-GAF, DESI_DPS-GAF, DESI_HC-GAF, and DESI_IDT-GAF models, which are -0.15, -0.43, -0.13, and -0.14, respectively.

Table 7. The influence of digital economy and society on green accounting finance: Short-run and long-run effects

	(1)	(2)	(3)	(4)	(5)
VARIABLES	DESI-GAF	DESI_CONN-GAF	DESI_DPS-GAF	DESI_HC-GAF	DESI_IDT-GAF
	Short-run impact				
EC term	-0.26*	-0.15***	-0.43***	-0.13***	-0.14***
	(0.022)	(0.0813)	(0.015)	(0.001)	(0.011)
D.DIGI	0.04	0.001	0.023	0.04	0.033
	(0.04)	(0.001)	(0.019)	(0.001)	(0.001)
	Long-run impact				
DIGI	-0.23***	-0.34***	-0.24**	-0.15**	-0.14**
	(0.012)	(0.001)	(0.002)	(0.009)	(0.001)
Observations	168	168	168	168	168

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations

4. 2. 2. ALTERNATIVE MEASURES OF DIGITALIZATION

This paper also employs more types of digitalization indexes to investigate their impact on GAF. The additional indexes include Internet user skills (*desi_hc_bsu*), Digital technologies for businesses (*desi_idt_dtb*), e-Commerce (*desi_idt_ecomm*), e-Commerce's turnover (*desi_idt_ecomturn*), Electronic information sharing (*desi_idt_eis*), Big data (*desi_idt_bigdat*), cloud (*desi_idt_cloud*), Artificial intelligence (*desi_idt_ai*), and SMEs selling online (*desi_idt_smeso*). The content is carried out utilised two panels: Panel A represents the results obtained from the PCSE approach, and Panel B shows the results of the FGLS approach. The results of both estimates are relatively similar. Regarding the PCSE results, the DESI dimensions generally have a significant positive impact on green accounting finance, except for e-commerce, e-commerce turnover, Big data, and SMEs selling online. Specifically, with a coefficient standing at 0.79 and statistically significant at 1% significance level, cloud computing services apparently have the most significant effect on green accounting finance, suggesting that the investment in cloud computing services including hosting of the company's database, accounting software methods, CRM software, computing energy is the most efficient way to benefit activities of the green accounting finance sector. Turning to the FGLS results, besides rejecting relationships like PCSE results, it also ignores the existence of the link between Digital technologies for businesses and green accounting finance. Regarding some notable control variables, while economic growth (*INC*) exhibits a favorable influence on green accounting finance, trade share (*EXP*) and circularity performance (*CE_MW*) trends seem to be in the opposite direction. Moreover, industrialization level (*IND*) remains an insignificant factor in explaining the fluctuations of green accounting finance.

Table 8. Effects of digital economy and society on green accounting finance: More types of digitalization index

Panel A: PCSE estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PCSE								
VARIABLES	GAF	GAF	GAF	GAF	GAF	GAF	GAF	GAF	GAF
L.desi_hc_bsu	0.11**								
	(0.046)								
L.desi_idt_dtb		0.10*							
		(0.054)							
L.desi_idt_ecomm			0.11						
			(0.088)						
L.desi_idt_ ecomturn				0.05					
				(0.044)					
L.desi_idt_eis					0.32***				
					(0.096)				
L.desi_idt_bigdat						0.09			
						(0.155)			
L.desi_idt_cloud							0.79**		
							(0.313)		
L.desi_idt_ai								0.72***	
								(0.240)	
L.desi_idt_smeso									0.00
									(0.027)
L.INC	3.58***	4.72***	4.08***	4.05***	3.68***	4.18***	6.63***	4.19***	4.10***
	(0.880)	(1.224)	(1.006)	(1.006)	(0.901)	(1.027)	(1.908)	(1.087)	(1.023)
L.EXP	-3.07***	-3.30***	-3.41***	-3.40***	-2.96***	-3.12***	-3.24***	-3.33***	-3.18***
	(0.697)	(0.713)	(0.765)	(0.788)	(0.685)	(0.698)	(0.693)	(0.747)	(0.702)
L.GE	-0.45	0.80***	0.26	0.27	-0.01	0.35*	1.89***	1.08***	0.31
	(0.349)	(0.299)	(0.207)	(0.204)	(0.244)	(0.196)	(0.524)	(0.339)	(0.199)
L.IND	0.14	-0.14	0.05	0.05	0.16	-0.02	-0.63	-0.21	0.03
	(0.294)	(0.342)	(0.290)	(0.287)	(0.284)	(0.293)	(0.493)	(0.332)	(0.295)
L.CE_MW	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.01***	0.00	-0.00***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
L.EI_ISO	-0.00***	-0.00	-0.00**	-0.00*	-0.00	-0.00**	0.01**	-0.00***	-0.00*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)
Observations	115	115	115	115	115	115	115	115	115
Number of nations	23	23	23	23	23	23	23	23	23

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Panel B: FGLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	FGLS								
VARIABLES	GAF	GAF	GAF	GAF	GAF	GAF	GAF	GAF	GAF
L.desi_hc_bsu	0.11*								
	(0.059)								
L.desi_idt_dtb		0.10							
		(0.073)							
L.desi_idt_ ecomm			0.11						
			(0.188)						
L.desi_idt_ ecomturn				0.05					
				(0.069)					
L.desi_idt_eis					0.32*				
					(0.167)				
L.desi_idt_bigdat						0.09			
						(0.249)			
L.desi_idt_cloud							0.79***		
							(0.163)		
L.desi_idt_ai								0.72**	
								(0.339)	
L.desi_idt_smeso									0.00
									(0.068)
L.INC	3.58***	4.72***	4.08***	4.05***	3.68***	4.18***	6.63***	4.19***	4.10***
	(0.930)	(0.995)	(0.895)	(0.897)	(0.908)	(0.922)	(0.969)	(0.880)	(0.900)
L.EXP	-3.07***	-3.30***	-3.41***	-3.40***	-2.96***	-3.12***	-3.24***	-3.33***	-3.18***
	(0.545)	(0.554)	(0.676)	(0.645)	(0.553)	(0.568)	(0.502)	(0.545)	(0.583)
L.GE	-0.45	0.80	0.26	0.27	-0.01	0.35	1.89***	1.08	0.31
	(0.799)	(0.765)	(0.690)	(0.687)	(0.695)	(0.695)	(0.705)	(0.764)	(0.698)
L.IND	0.14	-0.14	0.05	0.05	0.16	-0.02	-0.63*	-0.21	0.03
	(0.366)	(0.382)	(0.367)	(0.367)	(0.367)	(0.390)	(0.360)	(0.377)	(0.366)
L.CE_MW	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01**	0.00	-0.00
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
L.EI_ISO	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.01**	-0.00	-0.00
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
Observations	115	115	115	115	115	115	115	115	115
Number of nations	23	23	23	23	23	23	23	23	23

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations

5. DISCUSSION

Although previous research has highlighted the significance of the digital revolution in enhancing green accounting finance , empirical investigations into this relationship remain scarce. This study seeks to address this gap by offering a comprehensive empirical examination of the interplay between digitalization and green accounting finance. Utilizing a novel dataset from the European context, the analysis employs a diverse set of indicators to reflect the multifaceted dimensions of digitalization and its implications for environmentally sustainable financial practices. The integration of digital public services into Europe's material monitoring systems reveals both substantial opportunities and complex challenges. The primary objective of this research is to develop a theoretical framework that elucidates the mechanisms through which digitalization influences green accounting finance performance. By providing both theoretical insights and empirical evidence, this study aims to advance scholarly understanding of a relationship that has received limited attention in the existing literature. A central objective of this study is to empirically demonstrate that the integration of digital technologies into green accounting finance practices can serve as an effective instrument for advancing sustainability goals. For the European region to achieve long-term prosperity, it is imperative to enhance the efficiency and effectiveness of smart, digitally enabled green accounting systems.

6. CONCLUSION

This study aims to explore the question of whether digitization helps or hinders green accounting finance. Using four indices and nine dimensions, DESI was captured for the period 2010 – 2022 in 24 European countries. Economic growth, Trade share, level of democratization, Industrialization level, circularity performance, ISO 14001 certificates, Natural rents, Saving, Inflation, and Population could be applied to evaluate theories on this connection. The development and promotion of GAF have a good impact on DESI. DESI has detrimental long-term impacts on GAF, though. Additionally, stronger economic growth has a more favorable impact.

Our research shows that in order to achieve successful GAF, our findings indicate that the promotion of digitization is essential for the successful implementation of green financing initiatives across European countries. To achieve efficiency for the GAF, governments should concentrate on funding R&D in the digital sector. Companies need to work together in accordance with government regulations, boost funding for digitalization in its early stages, bolster R&D, and submit innovative, patentable solutions. Furthermore, in an unpredictable global economy, this study may serve as a model for nations looking to create the right instruments and plans to capitalize on the connection between digitization and GAF. Enhancing digitization translates toward bettering the ecosystem and public health. This contributes to the growth of a sustainable economy. Our subsequent debate highlights the significance of government even more. Therefore, there is a greater chance that DESI and GAF will have a good relationship in a better organizational setting. Good policy institutions foster an environment that encourages companies to invest more and upgrade transportation and industrial technologies; GAF gets better every day.

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REFERENCES

An, Q., Wang, R., Wang, Y., & Pavel, K. (2024). The impact of the digital economy on sustainable development: Evidence from China. *Frontiers in Environmental Science*, 12. https://doi.org/10.3389/fenvs.2024.1341471

Awosusi, A. A., Eweade, B. S., & Ojekemi, O. S. (2024). Analyzing the environmental role of resource efficiency, economic globalization, and biomass usage in Malaysia: A time-varying causal approach. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-024-05196-y

Beck, N., & Katz, J. N. (1995). What to do (and not to do) with Time-Series Cross-Section Data. *The American Political Science Review*, 89(3), 634–647. https://doi.org/10.2307/2082979

Bons, R. W. H., Alt, R., Lee, H. G., & Weber, B. (2012). Banking in the Internet and mobile era. *Electronic Markets*, 22(4), 197–202. https://doi.org/10.1007/s12525-012-0110-6

Bopp, R. E. (2020). Climate Change and Reputation in the Financial Services Sector. In T. Walker, D. Gramlich, M. Bitar, & P. Fardnia (Eds.), *Ecological, Societal, and Technological Risks and the Financial Sector,* 225–242. Springer International Publishing. https://doi.org/10.1007/978-3-030-38858-4_11

Boyer, M., & Laffont, J.-J. (1997). Environmental risks and bank liability. *European Economic Review*, 41(8), 1427–1459. https://doi.org/10.1016/S0014-2921(96)00034-7

Bu, M., Li, S., & Jiang, L. (2019). Foreign direct investment and energy intensity in China: Firm-level evidence. *Energy Economics*, 80, 366–376. https://doi.org/10.1016/j.eneco.2019.01.003

Chen, Y., Wang, L., & Yang, Y. (2024). An evaluation of the impact of China's green credit policy on different pathways using a CGE model. *Environmental Science and Pollution Research*, 31(10), 15379–15397. https://doi.org/10.1007/s11356-024-32062-1

Chiorazzo, V., D'Apice, V., DeYoung, R., & Morelli, P. (2018). Is the traditional banking model a survivor? *Journal of Banking & Finance*, 97, 238–256. https://doi.org/10.1016/j.jbankfin.2018.10.008

Dehnert, M. (2020). Sustaining the current or pursuing the new: Incumbent digital transformation strategies in the financial service industry. *Business Research*, 13(3), 1071–1113. https://doi.org/10.1007/s40685-020-00136-8

Dong, H., & Tao, M. (2022). The policy effect of green finance reform and innovations: Empirical evidence at the firm level. *PLOS ONE*, 17(12), e0278128. https://doi.org/10.1371/journal.pone.0278128

Du, Q., Pan, H., Liang, S., & Liu, X. (2023). Can Green Credit Policies Accelerate the Realization of the Dual Carbon Goal in China? Examination Based on an Endogenous Financial CGE Model. *International Journal of Environmental Research and Public Health*, 20(5), Article 5. https://doi.org/10.3390/ijerph20054508

Eklund, J., & Kapoor, R. (2019). Pursuing the New While Sustaining the Current: Incumbent Strategies and Firm Value During the Nascent Period of Industry Change. *Organization Science*, 30(2), 383–404. https://doi.org/10.1287/orsc.2018.1229

Evangelinos, K. I., & Nikolaou, I. E. (2009). Environmental accounting and the banking sector: A framework for measuring environmental-financial risks. *International Journal of Services Sciences*, 2(3/4), 366. https://doi.org/10.1504/IJSSCI.2009.026547

Fan, W., Wang, F., Liu, J., Yan, B., Chen, T., Liu, S., & Zhang, H. (2023). Environmental effects of financial agglomeration under dual correlations of industry and space: Evidence from 286 prefecture-level cities in China. *Environmental Impact Assessment Review*, 98, 106978. https://doi.org/10.1016/j.eiar.2022.106978

Gala, P., Camargo, J., Magacho, G., & Rocha, I. (2018). Sophisticated jobs matter for economic complexity: An empirical analysis based on input-output matrices and employment data. *Structural Change and Economic Dynamics*, 45, 1–8. https://doi.org/10.1016/j.strueco.2017.11.005

Garzaro, D. M., Varotto, L. F., & Pedro, S. de C. (2020). Internet and mobile banking: The role of engagement and experience on satisfaction and loyalty. *International Journal of Bank Marketing*, 39(1), 1–23. https://doi.org/10.1108/IJBM-08-2020-0457

Gray, R. (2002). Of Messiness, Systems And Sustainability: Towards A More Social And Environmental Finance And Accounting. *The British Accounting Review*, 34(4), 357–386. https://doi.org/10.1006/bare.2002.0217

Ha, L. T. (2022a). Are digital business and digital public services a driver for better energy security? Evidence from a European sample. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-17843-2

Ha, L. T. (2022b). Effects of digitalization on financialization: Empirical evidence from European countries. *Technology in Society*, 68, 101851. https://doi.org/10.1016/j.techsoc.2021.101851

Ha, L. T., & Thanh, T. T. (2022). Effects of digital public services on trades in green goods: Does institutional quality matter? *Journal of Innovation & Knowledge*, *7*(1), 100168. https://doi.org/10.1016/j.jik.2022.100168

Hwang, Y. K. (2023). The synergy effect through combination of the digital economy and transition to renewable energy on green economic growth: Empirical study of 18 Latin American and caribbean countries. *Journal of Cleaner Production*, 418, 138146. https://doi.org/10.1016/j.jclepro.2023.138146

Idris, A., & Rahman Razak, A. (2025). Energy Transition, Green Growth and Emission on Economic Growth using Spline Approach: Evidence From Asia-Pacific Countries. *ECONOMICS - Innovative and Economics Research Journal*, 13(2), 139–159. https://doi.org/10.2478/eoik-2025-0034

Labatt, S., & White, R. R. (2003). *Environmental Finance: A Guide to Environmental Risk Assessment and Financial Products*. John Wiley & Sons.

Le, T. H., & Bach, N. T. (2022). Global sanctions, foreign direct investment, and global linkages: Evidence from global data. *The Journal of International Trade & Economic Development*, *0*(0), 1–28. https://doi.org/10.1080/09638199.2022.2047218

Le, T. T. H., & Thi Hang Phan, N. (2024). Material footprint, economic growth, and climate change in emerging Southeast Asian markets. *Cogent Economics & Finance*, 12(1), 2386110. https://doi.org/10.1080/23322039.2024.2386110

Lenzen, M., Geschke, A., West, J., Fry, J., Malik, A., Giljum, S., Milà i Canals, L., Piñero, P., Lutter, S., Wiedmann, T., Li, M., Sevenster, M., Potočnik, J., Teixeira, I., Van Voore, M., Nansai, K., & Schandl, H. (2022). Implementing the material footprint to measure progress towards Sustainable Development Goals 8 and 12. *Nature Sustainability*, 5(2), 157–166. https://doi.org/10.1038/s41893-021-00811-6

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: Constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123–152. https://doi.org/10.1007/s11077-012-9151-0

Liu, L., & He, L.-Y. (2021). Output and welfare effect of green credit in China: Evidence from an estimated DSGE model. *Journal of Cleaner Production*, 294, 126326. https://doi.org/10.1016/j.jclepro.2021.126326

Liu, L., & Li, X. (2024). A Study on the Impact of Green Finance on the High-Quality Economic Development of Beijing–Tianjin–Hebei Region. *Sustainability*, 16(6), Article 6. https://doi.org/10.3390/su16062433

Lv, C., Bian, B., Lee, C.-C., & He, Z. (2021). Regional gap and the trend of green finance development in China. *Energy Economics*, 102, 105476. https://doi.org/10.1016/j.eneco.2021.105476

Ma, X., Feng, X., Fu, D., Tong, J., & Ji, M. (2024). How does the digital economy impact sustainable development? —An empirical study from China. *Journal of Cleaner Production*, 434, 140079. https://doi.org/10.1016/j.jclepro.2023.140079

Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy*, 44(2), 101856. https://doi.org/10.1016/j.telpol.2019.101856

Nurgaliuly, A., & Smagulova, S. (2025). Economic Assessment of Energy Security of the Regions of Kazakhstan. *ECONOMICS - Innovative and Economics Research Journal,* 13(2), 223–243. https://doi.org/10.2478/eoik-2025-0038

Pata, U. K., & Karlilar, S. (2024). The integrated influence of energy security risk and green innovation on the material footprint: An EKC analysis based on fossil material flows. *Journal of Cleaner Production*, 435, 140469. https://doi.org/10.1016/j.jclepro.2023.140469

Peng, H., Luo, X., & Zhou, C. (2018). Introduction to China's Green Finance System. *Journal of Service Science and Management*, 11(1), Article 1. https://doi.org/10.4236/jssm.2018.111009

Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. *Empirical Economics*, 60(1), 13–50. https://doi.org/10.1007/s00181-020-01875-7

Pousttchi, K., & Dehnert, M. (2018). Exploring the digitalization impact on consumer decision-making in retail banking. *Electronic Markets*, 28(3), 265–286. https://doi.org/10.1007/s12525-017-0283-0

Quan, T., & Quan, T. (2023). A Study of the Spatial Mechanism of Financial Agglomeration Affecting Green Low-Carbon Development: Evidence from China. *Sustainability*, 15(2), Article 2. https://doi.org/10.3390/su15020965

Richardson, B. J. (2009). Climate Finance and Its Governance: Moving to a Low Carbon Economy through Socially Responsible Financing. *The International and Comparative Law Quarterly*, 58(3), 597–626. https://www.jstor.org/stable/25622228

Salzmann, A. J. (2013). The integration of sustainability into the theory and practice of finance: An overview of the state of the art and outline of future developments. *Journal of Business Economics*, 83(6), 555–576. https://doi.org/10.1007/s11573-013-0667-3

Schandl, H., Marcos-Martinez, R., West, J., Miatto, A., Lutter, S., Lieber, M., Giljum, S., Lenzen, M., Li, M., Wang, H., Tanikawa, H., Krausmann, F., Eisenmenger, N., & Fischer-Kowalski, M. (2024). Global material flows and resource productivity: The 2024 update. *Journal of Industrial Ecology*, 28(6), 2012–2031. https://doi.org/10.1111/jiec.13593

Scholtens, B., & Zhou, Y. (2008). Stakeholder relations and financial performance. *Sustainable Development*, 16(3), 213–232. https://doi.org/10.1002/sd.364

Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics*, 74, 843–857. https://doi.org/10.1016/j.eneco.2018.07.020

Sisodia, A., & Maheshwari, G. C. (2023). Exploring Sustainable Finance: A Review and Future Research Agenda. *Vision*, 09722629231209177. https://doi.org/10.1177/09722629231209177

Srdelić, L. (2024). Transition Risks of Climate Change: An Analysis of Greenhouse Gas Emissions in Croatia and the Euro Area. *Oeconomica Jadertina, 14*(1), 74-90. https://doi.org/10.15291/oec.4433

Songini, L., Pistoni, A., Comerio, N., & Tettamanzi, P. (2023). A decade of integrated reporting studies: State of the art and future research implications. *Accounting, Auditing & Accountability Journal*, 36(9), 226–252. https://doi.org/10.1108/AAAJ-10-2021-5490

Sun, C., Li, Z., Ma, T., & He, R. (2019). Carbon efficiency and international specialization position: Evidence from global value chain position index of manufacture. *Energy Policy*, 128, 235–242. https://doi.org/10.1016/j.enpol.2018.12.058

Sun, G., Fang, J., Li, J., & Wang, X. (2024). Research on the impact of the integration of digital economy and real economy on enterprise green innovation. *Technological Forecasting and Social Change*, 200, 123097. https://doi.org/10.1016/j.techfore.2023.123097

Supporting the Green Transition of China's Financial System. (2022, January 24). https://www.nrdc.org/bio/alfonso-pating/supporting-green-transition-chinas-financial-system

Sweet, C. M., & Eterovic Maggio, D. S. (2015). Do Stronger Intellectual Property Rights Increase Innovation? *World Development*, 66, 665–677. https://doi.org/10.1016/j.worlddev.2014.08.025

Thompson, B. S. (2022). Blue bonds for marine conservation and a sustainable ocean economy: Status, trends, and insights from green bonds. *Marine Policy*, 144, 105219. https://doi.org/10.1016/j.marpol.2022.105219

Thompson, P., & Cowton, C. J. (2004). Bringing the environment into bank lending: Implications for environmental reporting. *The British Accounting Review*, 36(2), 197–218. https://doi.org/10.1016/j.bar.2003.11.005

Uribe-Linares, G. P., Ríos-Lama, C. A., & Vargas-Merino, J. A. (2023). Is There an Impact of Digital Transformation on Consumer Behaviour? An Empirical Study in the Financial Sector. *Economies*, 11(5), Article 5. https://doi.org/10.3390/economies11050132

Wang, J., & Zhang, G. (2022). Can Environmental Regulation Improve High-Quality Economic Development in China? The Mediating Effects of Digital Economy. *Sustainability*, 14(19), Article 19. https://doi.org/10.3390/su141912143

Wang, L., Wang, Z., & Ma, Y. (2022). Does environmental regulation promote the high-quality development of manufacturing? A quasi-natural experiment based on China's carbon emission trading pilot scheme. *Socio-Economic Planning Sciences*, 81, 101216. https://doi.org/10.1016/j.seps.2021.101216

Wang, W., Yang, X., Cao, J., Bu, W., Dagestani, A. A., Adebayo, T. S., Dilanchiev, A., & Ren, S. (2022). Energy internet, digital economy, and green economic growth: Evidence from China. *Innovation and Green Development*, 1(2), 100011. https://doi.org/10.1016/j.igd.2022.100011

Wang, Y., & Yun, M. (2013). Basic Framework for Building China's Green Financial System. In X. Li & J. Pan (Eds.), *China Green Development Index Report 2011,* 461–467. Springer. https://doi.org/10.1007/978-3-642-31597-8_20

Weber, O. (2014). The financial sector's impact on sustainable development. *Journal of Sustainable Finance & Investment*, 4(1), 1–8. https://doi.org/10.1080/20430795.2014.887345

Weber, O., Scholz, R. W., & Michalik, G. (2010). Incorporating sustainability criteria into credit risk management. *Business Strategy and the Environment*, 19(1), 39–50. https://doi.org/10.1002/bse.636

Wu, F., Yang, X., & Chen, Y. (2023). Research on innovative mechanisms of financial agglomeration enabling green coordinated development in the Yangtze River Delta of China. *Heliyon*, 9(3), e14172. https://doi.org/10.1016/j.heliyon.2023.e14172

Xiao, Y., Wu, S., Liu, Z. Q., & Lin, H. J. (2023). Digital economy and green development: Empirical evidence from China's cities. *Frontiers in Environmental Science*, 11. https://doi.org/10.3389/fenvs.2023.1124680

Xie, B., Yang, C., Song, W., Song, L., & Wang, H. (2023). The impact of environmental regulation on capacity utilization of China's manufacturing industry: An empirical research based on the sector level. *Ecological Indicators*, 148, 110085. https://doi.org/10.1016/j.ecolind.2023.110085

Xin, C., Fan, S., Mbanyele, W., & Shahbaz, M. (2023). Towards inclusive green growth: Does digital economy matter? *Environmental Science and Pollution Research*, 30(27), 70348–70370. https://doi.org/10.1007/s11356-023-27357-8

Xiufan, Z., Xiaomin, W., Wenhai, Z., & Ningning, F. (2024). Research on the green innovation effect of digital economy network – Empirical evidence from the manufacturing industry in the Yangtze River Delta. *Environmental Technology & Innovation*, 34, 103595. https://doi.org/10.1016/j.eti.2024.103595

Yang, S., Chen, Z., Umar, M., & Khursheed, A. (2022). Environmental regulation and high-quality sustainable development of China's economy – an empirical study based on a spatial durbin model and threshold model. *Economic Research-Ekonomska Istraživanja*, 35(1), 5699–5718. https://doi.org/10.1080/1331677X.2022.2035243

Yin, X., & Xu, Z. (2022). An empirical analysis of the coupling and coordinative development of China's green finance and economic growth. *Resources Policy*, 75, 102476. https://doi.org/10.1016/j.resourpol.2021.102476

Zhang, L., & Zhao, Y. (2023). Research on the Coupling Coordination of Green Finance, Digital Economy, and Ecological Environment in China. *Sustainability*, 15(9), Article 9. https://doi.org/10.3390/su15097551

Zhang, Z., Fu, H., Xie, S., Cifuentes-Faura, J., & Urinov, B. (2023). Role of green finance and regional environmental efficiency in China. *Renewable Energy*, 214, 407–415. https://doi.org/10.1016/j.renene.2023.05.076

Zhong, X., Cao, Z., Peng, B., & Cheong, T. S. (2023). Study on the coupling and coordination relationship between the digital economy and green development: Evidence from Guangdong province in China. *Frontiers in Environmental Science*, 11. https://doi.org/10.3389/fenvs.2023.1268601

Zhong, X., Duan, Z., Liu, C., & Chen, W. (2024). Research on the coupling mechanism and influencing factors of digital economy and green technology innovation in Chinese urban agglomerations. *Scientific Reports*, 14(1), 5150. https://doi.org/10.1038/s41598-024-55854-4