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Role of Industrial Digital Transformation in Improving Environmental Governance: A Study on the Non-Financial Sector of Saudi Arabia

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Abstract: The primary aim of this research is to delineate the significance of digital transformation (Digit) in enhancing environmental governance (ENG) within the non-financial sector of Saudi Arabia. The data was obtained from the annual reports of the non-financial sector in Saudi Arabia. The study utilised a deductive quantitative research methodology and employed a longitudinal research design. The nature of the research was explanatory, as it involved the development of theories and the formulation of hypotheses. The findings from the panel data analysis suggest that the variable Digit has a statistically significant and positive effect on the variable ENG. The aforementioned outcome suggests that the implementation of digital transformation has significantly contributed to the environmental governance practises within the non-financial sector of Saudi Arabia. Prior studies predominantly concentrated on various nations and sectors, inadvertently neglecting the manufacturing industry in Saudi Arabia. The capacity of digitalization, commonly referred to as digital technologies or the internet of things, to effectively tackle significant challenges in environmental governance has been emphasised, and recent studies have contributed to the current pool of knowledge on this subject matter. The implementation of improved governance practises has elucidated the existence of strategies to mitigate environmental concerns. Furthermore, it frequently offers a thorough examination of the scope, acceptance, implementation, and methodology crucial for achieving sustainable societal and ecological advancements in the long run. Furthermore, the outcomes of this study hold significant practical implications in addition to their contribution to policy development. The study focused on the non-financial sector, specifically examining the influence of digitalization on the economic performance of non-financial industries in Saudi Arabia. Therefore, this research can be regarded as a groundbreaking study that incorporates an expanded model to analyse the influence of digital technology on the field of English language and literature.

Introduction

The convergence of conventional sectors with the internet within the information economy is expediting the rapid evolution of the global economy towards enhanced levels of innovation, intelligence, and sustainability. The phenomenon of accelerated urbanisation and industrialisation has presented nations worldwide with unprecedented development prospects, albeit accompanied by notable environmental challenges that render the sustainability of ongoing global economic growth questionable (Ren, Hao, & Wu, 2023). An imperative concern in the realm of sustainable development within the global economy pertains to the preservation of ecological equilibrium (Wan et al., 2023).

In light of the escalating challenges posed by global warming and the growing concerns surrounding resource and environmental limitations, individuals have progressively recognised the importance of safeguarding the environment. Consequently, they have begun to actively pursue avenues for environmental governance (ENG) (Li et al., 2019b). Through the establishment of foundational laws and regulations aimed at environmental protection and the development of a comprehensive framework for global environmental governance (ENG), several international environmental laws have been promulgated to guide international collaboration in addressing climate change. Many countries have been adopting environmental policies tailored to their specific industrial conditions as part of their ongoing efforts to enhance their economic structure (Li et al., 2019b).

However, the juxtaposition of environmental pollution and economic growth has become increasingly conspicuous, presenting unparalleled challenges on a global scale (Li et al., 2019a). Based on the notion of institutional legitimacy, it is posited that social organisations are unable to sustain and progress unless they adhere to the conditions outlined in an implicit social agreement. Scholarly discourse has contended that enterprises ought to embrace ethical environmental management practises as a means to effectively address the public's expectations arising from an implicit agreement, thereby attaining environmental legitimacy (Nègre et al., 2017). Regrettably, agency issues arise due to the separation of ownership and management within an organisation, leading managers to prioritise their personal interests over the interests of stockholders (Wang, Zhou, & Xu, 2018).

Management compensation in businesses is often structured in the form of performance pay, whereby the remuneration of managers is directly linked to the overall success of the company. Environmental investments can result in increased business costs, exert a detrimental influence on overall short-term performance, and adversely affect management compensation. Executives exhibit a lack of motivation to promote environmental governance (Goodman et al., 2016). The existence of knowledge disparities between two parties can be attributed to the inherent flaws in systems governing the exchange of information between shareholders and enterprises, as well as the disclosure of enterprise information (Jovanović, Dlačić, & Okanović, 2018). According to Evans (2012), companies that possess opportunistic tendencies tend to reduce their investments in environmental protection and increase their unlawful pollution discharge in situations where there is a lack of information symmetry.

The potential resolution of past challenges lies in the remarkable flexibility and ease of use of digital technology, which has the capacity to eliminate any existing divide between businesses and consumers in the context of digitalization (Bakker & Ritts, 2018). The information disclosure system of firms towards stakeholders may experience substantial changes within the digital environment, as digitalization becomes deeply embedded in the operational management and company mechanisms of manufacturing (Hinings, Gegenhuber, & Greenwood, 2018). Hence, the process of digitalization has the potential to effectively reduce the disparities in information and costs associated with interactions between manufacturing entities and various stakeholders. Additionally, it can mitigate the inclination of managers towards engaging in opportunistic behaviour and exhibiting personality-driven decision-making tendencies. Furthermore, digitalization can impose constraints on managers' discretion to determine the timing of pollutant release, while simultaneously fostering their commitment to the environmental goals of their respective organisations (Bakker & Ritts, 2018). The utilisation and progression of digital technology may exert a significant influence on the principles and practises of corporate governance within the context of the digital era, consequently affecting the economic value generation of manufacturing firms (Ren, Hao, & Wu, 2023).

In recent years, there has been scholarly discourse surrounding the potential impact of digitalization on environmental quality, specifically in relation to the increase in ENG (Kloppenburg et al., 2022). Furthermore, prior research endeavours aimed at addressing environmental challenges primarily centred on technological advancements and pollution, while giving scant consideration to environmental governance (Li & Guo, 2022; Ren, Hao, & Wu, 2023). Hence, the primary objective of this study was to examine the effects of digitalization on the field of English language and literature. The existing body of literature has primarily concentrated on developed economies (Chen & Hao, 2022; Oliveira & Siqueira, 2022; Ren, Hao, & Wu, 2023).

However, there has been a notable dearth of research on developing economies, particularly in the context of Saudi Arabian manufacturing companies. This gap in the literature can be attributed to the predominant focus on other sectors in previous studies (Chen & Hao, 2022; Oliveira & Siqueira, 2022; Ren, Hao, & Wu, 2023). The manufacturing sector is distinguished from other industries due to its unique characteristics. Still, the manufacturing sector assumes a pivotal role in safeguarding state resources, promoting comprehensive economic growth, and bolstering regional development. It functions as a significant provider of manufacturing goods, particularly in the realm of agricultural manufacturing methodologies. Since 1976, there has been a notable expansion of Saudi Arabia's transport infrastructure, which has occurred in conjunction with the region's GDP development (Magazzino & Mele, 2021).

The manufacturing sector in Saudi Arabia has a significant history and has experienced rapid growth, leading to temporary resolutions for various social issues (Udemba, Magazzino, & Bekun, 2020). These issues include the substantial pollution of gas, water, and residual waste, as well as a deficiency in sufficient resource assets. The proliferation of advanced technologies has resulted in a multitude of social issues in Saudi Arabia, leading to a significant deterioration in air quality and subsequent environmental degradation. There has been a significant level of public concern regarding the incidence of environmental degradation, ecological damage, and emissions associated with manufacturing activities in certain locations.

According to reports, the number of lawsuits pertaining to environmental and resource-related matters that were adjudicated through the judicial system in 2020 amounted to approximately 253,000. In the context under consideration, Saudi Arabia presents the concept of establishing an ecological civilization alongside the pursuit of enhancing the aesthetic appeal of the country, thereby suggesting a novel framework that aligns with the principles and values of said civilization. Notwithstanding the aforementioned impact, the reduction of pollution levels is conducive to fostering sustainable economic growth (Magazzino, Mele, & Schneider, 2021; Mele & Magazzino, 2020). The study of engineering (ENG) and its significance in the context of manufacturing operations is of utmost importance. Prior scholarly research has similarly posited that the process of digitization transformation has been instrumental in enhancing governance (Shen, Zhang, & Liu, 2022; Wen, Wen, & Lee, 2022). Therefore, this concept could not be ignored to improve the ENG.

In light of the preceding discourse, the objective of this study is to investigate the impact of "digital transformation" (Digit) on the engineering (ENG) function within manufacturing organisations in Saudi Arabia. The article presents a set of distinct concepts that can be categorised into three primary groups. Initially, there is a limited body of research examining the impact of corporate governance on environmental conservation. This scarcity can be attributed to the prevailing focus in the existing literature on the influence of digital transformation on enhancing organisational management and outcomes within enterprises.

In order to expand the scope of research on the financial impacts of Digit, this study examines the relationship between Digit and ENG within the context of the evolving fusion of the internet economy and "environmentally friendly development of manufacturing companies". Secondly, the prevailing body of research primarily examines factors that influence corporate environmental performance (ENG) through the lens of internal governance systems and managerial heterogeneity. However, there is limited attention given to the influence of a firm's information processing capabilities on its own ENG. Consequently, this study investigates the strategic impact of digital companies on environmental, social, and governance (ENG) factors, contributing to the existing literature on the influence of organisational environments on ENG.

This study examines the internal mechanisms involved in the digital transformation of manufacturing companies and its effects on engineering. This study examines the non-economic efficiency of manufacturing firms enabled by digital transformation through the analysis of a theoretical black box. The unpacking of this black box is achieved through the utilisation of micro-tests that rely on large samples. This paper presents a theoretical framework that aims to facilitate the promotion of enhanced social responsibility among manufacturing companies in the context of the digital age.

The research was structured into five chapters, each serving a distinct purpose. The initial chapter provided an introduction to the study. The second chapter encompassed a comprehensive review of the existing literature. The third chapter focused on the research methodology employed. The fourth chapter involved the analysis of the collected data and the subsequent outcomes. Lastly, the fifth chapter encompassed the discussion and conclusion of the study.

Literature Review and Hypothesis Development

In light of the current prominence of ecological civilization construction, it is imperative for financial institutions, investors, governments, and other stakeholders to carefully consider the incorporation of environmental protection measures within business operations. The media serves as an intermediary for digital transformation, facilitating the collection, processing, and dissemination of data. This process is advantageous as it improves investors' ability to access relevant information (Chen, 2017). The significance of media in the intermediation of capital market information is increasing due to advancements in information technology and the widespread adoption of the Internet (Lee-Geiller & Lee, 2022; Strycharz, Strauss, & Trilling, 2018).

The most valuable intangible asset of an organisation is its reputation (Prieto, Phipps, & Addae, 2014). In order to attract and retain customers, financiers, and employees, businesses will need to actively disassociate themselves from environmental contamination, allocate greater resources towards ecological sustainability, and recognise the significance of their reputation. According to O'Flynn (2021), the theory of public value posits that the process of public decision-making should prioritise the identification and fulfilment of the collective preferences of the general public. The approval and gratitude of citizens serve as a paramount indicator of government performance (Filgueiras et al., 2021; Xu, Chen, & Dai, 2022). When the general public becomes informed via media channels about a company's environmental concerns, the government will adopt proactive measures to incentivize the company to enhance its environmental performance, aligning with the preferences and demands of the public.

In response to concerns regarding legitimacy, Businesses will increasingly embrace proactive environmental management practises (ENG) in order to enhance their environmental performance (Bansal & Roth, 2000). The digital transformation of the media, known as Digit, has a significant impact on their ability to observe and report on the information environment within the manufacturing sector, and vice versa. Furthermore, the media facilitates the accessibility of information regarding a company's environmental performance for banks, investors, and governments. With the objective of cultivating a positive public perception regarding environmental conservation endeavours, businesses are motivated and obligated to increase their financial commitment towards environmental protection and bolster their environmental governance practises.

Accounting information congruity refers to the accurate representation of the distinct economic circumstances of reporting entities through financial reports, including financial statements and financial measurements, as stated by Guimarães and Rover (2022) and Kun and Nan (2021). The utilisation of comparable accounting data has the potential to reduce costs associated with information processing and acquisition, enhance decision-making capabilities, and provide additional protection for information consumers (Mohd Amin & Abdul-Rahman, 2020). Comparable accounting information is an essential source of information for decision-making by users of information. If accounting standards for information congruity are lenient, businesses will have greater flexibility in manipulating financial data during disclosure (Bertomeu, Ma, & Marinovic, 2020).

In the absence of a robust mechanism to enforce comprehensive disclosure of pertinent environmental

information by businesses, there exists a heightened probability that companies can conceal such data with minimal likelihood of facing adverse consequences (Doshi, Dowell, & Toffel, 2013; Tassabehji, Hackney, & Popovič, 2016). In such circumstances, it is probable that the company will prioritise economic rationality over taking actions to mitigate pollution or enhance investments in environmental protection, thereby opting to withhold information. This practise is deemed detrimental to the sustained development of businesses due to its adverse effects on environmental regulation, negative impact on shareholder interests, and hindrance to company expansion. The primary aim of digitization, facilitated by digital technologies, is to convert corporate data generated during the various activities of organisations, including production, operation, and management.

The accounting information system has the capability to transform unprocessed data into significant financial metrics, as demonstrated by the research conducted by Xu, Chen, and Dai (2022). This alteration enhances the company's method of transmitting information and improves its efficiency, thereby enhancing the overall information environment of the company. Additionally, it contributes to the comparability of the company's accounting information. The inclusion of environmental data is imperative when compiling a Corporate Social Responsibility (CSR) report. The disclosure of non-financial information pertaining to businesses has been enhanced due to the implementation of Digit.

There is a positive relationship between the level of openness in a business's information environment and the congruity of its financial statements (Kothari, So, & Verdi, 2016). Previous studies have demonstrated that enhancing the consistency of accounting information can lead to higher expenses associated with non-compliance with regulations mandating the divulgence of confidential data (Kim, Kraft, & Ryan, 2013; Lucatello & Leconte, 2021). This improvement incongruity could be facilitated by the implementation of Digit, thereby incentivizing business executives to allocate additional funds towards environmental protection measures. The rationale behind the adoption of Digit lies in its potential to serve as a fundamental framework for enhancing environmental governance.

Therefore, an organisation's digitization efforts can yield both favourable and unfavourable consequences (Yeow, Soh, & Hansen, 2018). The positive consequences encompass enhanced production efficiency and performance, whereas the negative consequences encompass failure (Hermes et al., 2020). Digit has demonstrated significant contributions in various aspects, such as production effectiveness, performance, market standing, and responsiveness. Digit has increased the overall efficiency of businesses by enhancing their capacity for innovation and promoting the synchronised development of advanced manufacturing and service sectors (Karthiga, Keerthiga, & Preethi, 2019).

In relation to the impact of digitization on business performance, the concept of "digital product innovation" enables businesses to promptly adapt to market fluctuations (Chang & Li, 2022; Singh & Hess, 2020). Engaging in real-time communication with clients can enhance their ability to meet their specific needs more efficiently (Nadkarni & Prügl, 2021). Enhanced business efficiency and competitiveness by adhering to the principles outlined in the study conducted by Skog, Wimelius, and Sandberg (2018), which emphasises the importance of augmenting the value of your product or service for customers (Dimitrov, 2016). The advent of Digit

has led to enhanced information-gathering capabilities for businesses through the widespread adoption of digital tools, while their ability to integrate information technology-enabled resources has undergone continuous refinement (George & Schillebeeckx, 2022).

An examination of the impact of Digit on the liquidity of enterprise stocks reveals that it contributes to an elevation in the liquidity levels of enterprise stocks. This effect is achieved through the enhancement of business performance, the augmentation of innovativeness value, and the assurance of financial strength (Chen et al., 2022). The impact of Digit on earnings management is characterised by its constraining effect on managers' pursuit of self-interest. This is achieved through the facilitation of efficient and transparent resource operations within companies, as well as the dissemination of pertinent information (Luo & Wu, 2021). In relation to the impact of Digit on tangible financialization, it serves to enhance internal governance, augment company expenditures on research and development, and generally mitigate the pace of excessive financialization (Fang, Perc, & Zhang, 2022; Schinagl & Shahim, 2020; Xu, Chen, & Dai, 2022).

Conversely, although digital technologies have been found to have favourable implications for business value creation, they can also engender detrimental outcomes (Ziyadin, Suieubayeva, & Utegenova, 2020). While Digit has undoubtedly contributed to the maturation of the business model, it is inevitable that it will result in increased overhead and salary expenses. Contrary to assertions made, the implementation of Digit does not yield substantial enhancements in enterprise performance (Ekata, 2012), primarily attributable to the considerable expenses involved.

The effectiveness of decision recommendations generated by digital technology is subject to scrutiny due to the uncritical dependence on it, without taking into account emotional factors (Logg, Minson, & Moore, 2019). Both chief executive officers (CEOs) and regular employees have experienced salary increases due to the implementation of Digit. However, it is noteworthy that the latter group has observed a more substantial growth in their compensation, thereby exacerbating the income disparity within the organisation (Fang, Perc, & Zhang, 2022; Xu, Chen, & Dai, 2022).

Existing scholarly works predominantly focus on the examination of environmental performance, rather than establishing a cohesive framework for defining theories and metrics pertaining to corporate environmental, social, and governance (ENG) indicators. This literature predominantly focuses on the various factors that influence corporate environmental, social, and governance practises, encompassing both internal and external drivers. The government (Lei, Huang, & Cai, 2022), the media (Xu, Chen, & Dai, 2022), and non-profit organisations (Bakhsh Magsi et al., 2018) can be considered as external motivators. The implementation of environmental regulations by the government has been found to have a deterrent impact, leading to reduced levels of pollution emissions and increased adherence to these regulations by businesses (D'Amato et al., 2018; Earnhart, Harrington, & Glicksman, 2020).

However, research conducted by Prechel (2021) indicates that government enforcement alone is insufficient to incentivize businesses to invest in pollution-control technology. The research conducted by Xu et al. (2018) suggests that media coverage has the potential to enhance a company's environmental performance by fostering a proactive attitude towards sustainability. It has been

observed that enhancing the environmental performance of corporations can be achieved through an increase in the allocation of green investment sources within the financial sector (Esposito et al., 2023; Yan, Almandoz, & Ferraro, 2021).

"Corporate social responsibility (CSR), research and development (R&D)", internal motivation encompasses both spending and good corporate governance within its purview. Shive and Forster (2020) posit that there exists a negative correlation between board size, cooperative fund ownership, and pollution in public companies. Their findings imply that enhanced oversight mechanisms could potentially mitigate externalities. According to the study conducted by Akram, Abrar-ul-Haq, and Raza (2018), An examination of the influential factors of corporate environmental governance suggests that an increase in ownership positively influences the promotion of environmental sustainability within the manufacturing sector. In their study, Alam et al. (2019) made a significant finding that allocating resources towards research and development (R&D) activities has a positive impact on environmental performance by reducing energy consumption and carbon emissions.

Furthermore, a study conducted by Lin and Xu (2022) revealed that enhancing the research and development (R&D) intensity of Chinese manufacturing has the potential to reduce pollutant emissions. The study conducted by Kraus, Rehman, and García (2020) provided empirical evidence of a positive correlation between corporate social responsibility (CSR) and both green technology adoption and environmental protection. This relationship was found to contribute to the improvement of environmental performance. According to Laari, Töyli, Solakivi, and Ojala's (2016) research, the adoption of green production methods by businesses has the potential to enhance their environmental performance, a fact that is recognised by shareholders.

Numerous empirical studies have been undertaken to examine the association between Digit and ENG. An investigation conducted by Xu, Chen, and Dai (2022) revealed a statistically significant and positive impact of Digit on ENG. The research was carried out on Chinese corporations, with data being gathered from their annual reports. Previous research has also identified a noteworthy and statistically significant impact on environmental governance (Zhang, Dong, & Yao, 2022). Previous studies have reported a statistically significant and adverse impact on environmental governance (Kloppenburg et al., 2022; Kruk et al., 2021). These studies provide evidence of a relationship between Digit and ENG. Therefore, following research hypothesis is expressed below,

H1: Digital Transformations have substantial effect on environmental governance of non-financial sector in Saudi Arabia.

Research Methodology

The data was collected over a span of ten years, specifically from 2011 to 2021, encompassing non-financial corporations listed on the Saudi Stock Exchange. This temporal phase facilitates the examination of the association between Digit and Saudi Arabia ENG within the framework of non-financial manufacturing. According to the environmental and climate breakdown index, Saudi Arabia ranks as the fifth most vulnerable nation. The non-financial sector in Saudi Arabia is currently confronted with a challenging predicament. Therefore, Saudi Arabia is diligently endeavouring to enhance its environmental conditions through the advancement of its technological capabilities.

The companies with missing values were excluded from the sample. Furthermore, companies with a gearing ratio below 1.150 were excluded from the sample and data collection process. The sources utilised for data collection included the data stream and annual reports. The study employed a quantitative research design as it involved the collection and analysis of numerical data (Bloomfield & Fisher, 2019). Thus, the chosen research approach is deemed optimal for the current study. The research design employed in this study was longitudinal, as it involved the collection of data at various time points spanning from 2011 to 2021 (Creswell & Creswell, 2003). Furthermore, the study employed an explanatory research design, in which hypotheses were formulated and theories had previously undergone testing (Creswell & Creswell, 2003).

Model and Measurements

The regression model in this study has been formulated based on the research objective. The primary aim of this study is to examine the effects of digitalization transformation on the environmental governance practises of manufacturing companies in Saudi Arabia. In order to achieve the intended objective, the data utilised in this study was obtained from secondary sources, enabling the application of panel data analysis techniques. Hence, the research model employed the utilisation of the following equation to conduct panel data analysis.

$$ENG = a_0 + b_1 digit + b_2 ROA + B_3 Leverage + b_4 LSG + b_{5l} NDG + b_5 CEOD + Uit$$

In the aforementioned model, the variable of interest is environmental governance (ENG), which is operationalized as the natural logarithm of investment in environmental protection specifically within the manufacturing sector. The exogenous variable of digitalization transformation (Digit) was assessed through the compilation, comparison, and incorporation of digital characteristic data obtained from annual reports of publicly traded companies. This process resulted in the creation of a comprehensive thesaurus, to which a value of 1 was added before calculating the natural logarithm.

The control variables in this study include return on assets (ROA), leverage, large shareholder governance (LSG), independent directors (IND), and CEO duality. ROA is measured by net income divided by total assets, while leverage is evaluated by the ratio of liabilities to total assets. LSG is determined by analysing the ownership structure of the largest shareholdings. IND is measured by the proportion of independent directors to the size of the board. Lastly, CEO duality is assessed using a di (Gill & Mathur, 2011; Rechner & Dalton, 1991; Xu, Chen, & Dai, 2022). The aforementioned measurements were obtained from the studies mentioned below.

Empirical Results and Analysis

Descriptive Statistics

The descriptive statistics for the main variable are presented in Table 1. The average value of digital transformation is 0.4782, indicating that over 50% of companies did not implement a digital transformation strategy. The mean value of profitability was observed to

be 0.0452, indicating that manufacturing companies generally exhibit low levels of profitability. The manufacturing companies exhibit a mean value for financial leverage of 0.4723, suggesting a relatively high level of financial leverage. The data indicates that a significant proportion of shareholder governance exhibits a mean value of 0.4292, suggesting the presence of established share dominance. The metric for independent director governance (ID) exhibits a mean value of 0.4320, suggesting that manufacturing firms possess an adequate number of independent directors to fulfil their regulatory responsibilities. The aforementioned descriptive values are anticipated and presented in Table 1.

Table1: Descriptive Statistics

	Mean	Minimum	Maximum	SD
Digit	0.4782	0	3.6722	0.6723
ROA	0.0452	-0.5632	0.7621	0.321
Leverage	0.4723	-0.0067	0.8731	0.2134
LSG	0.4292	0.0273	0.843	0.1783
INDG	0.4320	0.1234	0.6234	0.04532
CEOD	0.1378	0	1	0.2832

Note: digit-digital transformation, ROA-return on assets, LSG-large shareholder governance, INDG-independent governance, CEOD-CEO duality.

Regression analysis

In this study, the regression analysis was conducted subsequent to the computation of descriptive statistics. The regression results are displayed in the pooled model. After taking into account the control variables and setting the significance level at 5%, the digital transformation was quantified through descriptive statistics and regression analysis. The findings from the pooled model regression analysis reveal that the t-value associated with digital transformation is 2.63. This observation highlights the strong correlation between digital transformation and the environmental governance of manufacturing companies.

The degree to which digital transformation has expanded will result in a corresponding rise in the environmental governance practises of manufacturing companies. Therefore, the preceding hypothesis has been validated. In order to address the issue of endogeneity, we employed panel data fixed-effect models for testing purposes, as indicated in Table 2. The findings from the fixed effects model regression analysis reveal that the coefficient value for digital transformation is 0.3864, with a corresponding t value of 3.78. Additionally, we employed the "robust and cluster robust standard error tests". The results presented in Table 2 demonstrate robustly indicated positive regression coefficients.

Table 2: Pooled and Fixed effect model Results

Variables	Pooled	Fixed-Effect Model	Robust	Cluster
Digit	0.3864(2.63)	0.3574 (2.53)	0.3860 (3.78)	0.3574(1.80)
ROA	51.7534(36.07)	51.7556 (36.07)	51.5612 (12.66)	51.4612(14.09)
Leverage	−0.8278(−1.65)	−0.8278 (−1.65)	−0.8670 (−1.31)	−0.8467 (−1.00)
LSG	1.4877(2.22)	1.4877(2.22)	1.3878 (1.52)	1.3878 (1.62)
INDG	−2.2219 (−1.32)	−2.2219 (−1.32)	−2.2219 (−1.26)	−2.2219 (−1.11)
CEOD	−0.2125 (−0.87)	−0.2125 (−0.87)	−0.2125 (−0.82)	−0.2125 (−0.83)
Constant	13.5248(15.31)	13.5248(15.31)	0.9602(3.84)	13.5248(12.31)
R2	0.4250	0.4081	0.4250	0.4250

Note: digit-digital transformation, ROA-return on assets, LSG-large shareholder governance, INDG-independent governance, CEOD-CEO duality.

Dummy Variables Analysis

The dummy variables are displayed in Table 3. The dummy variables, referred to as (Digita_dummy), are employed as a means to symbolise the process of digital transformation undertaken by manufacturing companies. The numerical value "1" represents the presence of digital transformation within manufacturing firms, whereas the numerical value "0" represents the absence of digital transformation within these firms. The linear regression analysis for Model 1 was performed in the following manner. The regression coefficient demonstrates a noteworthy impact of the digital transformation on environmental governance (ENG), suggesting that the digital transformation has a more pronounced influence on ENG compared to manufacturing companies that have not embraced this transformation (Digit). The indicators pertaining to digital technology within companies were categorised into two primary groups. There are two primary aspects to consider when examining the role of technology: adopted technology, also known as digital-basic, and practical application, also referred to as digital-used.

The calculation of digital-basic is primarily based on the aggregation of word frequencies. These frequencies are associated with various technologies such as information technology, blockchain technology, artificial intelligence technology, and cloud computing technology, as reported annually by

companies. The total word frequency is determined by incrementing it by one and applying the natural logarithm. The practical application of digital technologies has been assessed by analysing the frequency of word usage in the annual reports of the listed companies. By incorporating a natural logarithm, it has been determined that from a fundamental standpoint, the impact on ENG is positive but not statistically significant. However, the usage of digits has a positive and statistically significant effect on ENG. The findings of this study demonstrate that the implementation of digital technology within manufacturing companies has a positive impact on its contribution to engineering. The aforementioned findings are anticipated and presented in Table 3 below.

Table 3: Substitution Variable Results

	ENG	ENG	ENG
Digital dummy	0.7528 *** (3.46)		
Digital-basic		0.2244 (0.98)	
Digital-used			0.4008(2.50)
ROA	52.0477(36.43)	51.8457(36.11)	51.6698(35.99)
Leverage	0.1229 (0.87)	−0.8210 (−1.63)	−0.8428(−1.68)
LSG	2.5888(4.47)	1.3833(2.21)	1.3914(2.23)
IDG	−1.4714 (−0.88)	−2.0810(−1.23)	−2.2393 (−1.33)
CEOD	−0.1801 (−0.74)	−0.2022 (−0.83)	−0.2044 (−0.84)
Constant	12.7414 (17.15)	13.35845(15.23)	13.5648(15.35)
R2	0.3962	0.4240	0.4250

Note: digit-digital transformation, ROA-return on assets, LSG-large shareholder governance, INDG-independent governance, CEOD-CEO duality.

Discussion and Contributions

The proliferation of digital technologies, such as blockchain, big data analysis, digital transformation, and artificial intelligence, in the present decade has emerged as a significant catalyst for the advancement of environmentally sustainable practises by businesses. This study employs text manufacturing techniques to construct digital transformation (Digit) data pertaining to the green development of manufacturing companies. A sample of manufacturing companies in Saudi Arabia was chosen to examine the correlation between Digit and ENG within the manufacturing sector.

The findings of this study indicate that the implementation of digital technologies in manufacturing firms positively impacts the efficiency of engineering processes. The results of the path tests suggest that the implementation of numerical techniques and the strengthening of media oversight have led to improvements in the field of engineering (ENG). The aforementioned findings suggest that digitalization has played a significant role in augmenting ENG (economic growth), thereby contributing to the sustainable development of organisations and enhancing their competitive advantage. Previous research has also posited that advancements in digitalization have the potential to result in the enhancement of the ENG (De Blust, Paelinckx, & Kuijken, 1994; Siryk et al., 2021).

Prior studies predominantly concentrated on various nations and sectors, inadvertently neglecting the manufacturing industry of Saudi Arabia. The capacity of digitalization, which encompasses digital technologies and the Internet of Things, to effectively tackle significant challenges in the field of engineering has been emphasised. In addition, recent research has contributed to the current understanding of this subject matter. Enhanced governance practises have elucidated strategies for mitigating environmental concerns. Furthermore, it frequently offers a thorough examination of the scope, acceptance, implementation, and intricacies crucial for sustainable societal and ecological advancement. Moreover, this research endeavour possesses the capacity to make a valuable contribution to the advancement of policy formulation, while simultaneously offering practical implications.

The growing digital economy is assuming greater importance in facilitating the environmentally sustainable development of businesses. It is imperative for Saudi Arabia to seize the opportunity afforded by Digit, enhance its backing for Digit enterprises, and optimise the utilisation of digital transformation to harness its advantages and expedite the expansion of environmentally sustainable businesses. Secondly, a linkage between Digit and ENG is established by leveraging external regulatory authorities, such as media oversight. Consequently, the implementation of media oversight serves as a powerful tool in mitigating environmental issues, thereby compelling an increasing number of enterprises to embrace environmental protection policies. Thirdly, it is imperative to address the opaque nature of business-related environmental challenges by establishing a continuous and transparent dissemination of information.

This can be achieved through the disclosure of pertinent environmental data by corporations. In light of the study's findings, recommendations are put forth regarding policies that could potentially facilitate sustainable development in emerging markets. The initial measure entails the reduction of environmental impact by government operations. In order to integrate sustainability into procurement management practises, it is imperative for agencies to implement concrete measures in the form of environmental standards. The establishment of a circular economy, characterised by a significant reduction in emissions and the promotion of green and renewable technologies, can be facilitated through the utilisation of appropriate digital tools.

Limitations and Future Directions

This study is subject to several limitations. This study primarily examined the economic ramifications of the digital transformation of firms in the context of promoting sustainable development. However, it did not extensively investigate the inhibiting factors associated with the digital transformation of firms. Another constraint of these studies is their focus on analysing the effects of Digit on ENG within the specific context of manufacturing companies and emerging mechanisms of internal operations. Nevertheless, this study did not examine the potential impact of heterogeneity on both individual and corporate managers.

Furthermore, it should be noted that the scope of this study was confined to manufacturing companies in Saudi Arabia, a developing nation. As a result, the findings may have limited applicability when compared to more advanced economies. Consequently, it is recommended that future research endeavours explore other developed countries in order to ascertain potential variations in the outcomes. Furthermore, the study employed a longitudinal research design, although it is worth noting that there exist alternative approaches such as cross-sectional and mixed-method studies that can be utilised to assess the variability in the findings. Hence, it is recommended that future investigations employ a combination of mixed methods or a cross-sectional survey-based approach in order to enhance the robustness of the forthcoming study.

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References

Akram, F., Abrar-ul-Haq, M., & Raza, S. (2018). A Role a Corporate Governance and Firm's Environmental Performance: A Moderating Role of Institutional Regulations. *International Journal of Management Studies, 25*(2), 19-37. Retrieved from https://ssrn.com/abstract=3703616

Alam, M. S., Atif, M., Chien-Chi, C., & Soytaş, U. (2019). Does corporate R&D investment affect firm environmental performance? Evidence from G-6 countries. *Energy Economics, 78*, 401-411. doi: https://doi.org/10.1016/j.eneco.2018.11.031

Bakhsh Magsi, H., Ong, T. S., Ho, J. A., & Sheikh Hassan, A. F. (2018). Organizational culture and environmental performance. *Sustainability, 10*(8), 2690. doi: https://doi.org/10.3390/su10082690

Bakker, K., & Ritts, M. (2018). Smart Earth: A meta-review and implications for environmental governance. *Global environmental change, 52*, 201-211. doi: https://doi.org/10.1016/j.gloenvcha.2018.07.011

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of management journal, 43*(4), 717-736. doi: https://doi.org/10.5465/1556363

Bertomeu, J., Ma, P., & Marinovic, I. (2020). How often do managers withhold information? *The Accounting Review, 95*(4), 73-102. doi: https://doi.org/10.2308/accr-52619

Bloomfield, J., & Fisher, M. J. (2019). Quantitative research design. *Journal of the Australasian Rehabilitation Nurses Association, 22*(2), 27-30. Retrieved from https://search.informit.org/doi/abs/10.3316/INFORMIT.738299924514584

Chang, X., & Li, J. (2022). Effects of the digital economy on carbon emissions in China: A Spatial Durbin econometric analysis. *Sustainability, 14*(24), 16624. doi: https://doi.org/10.3390/su142416624

Chen, P., & Hao, Y. (2022). Digital transformation and corporate environmental performance: The moderating role of board characteristics. *Corporate Social Responsibility and Environmental Management, 29*(5), 1757-1767. doi: https://doi.org/10.1002/csr.2324

Chen, T. (2017). Investor attention and global stock returns. *Journal of Behavioral Finance, 18*(3), 358-372. doi: https://doi.org/10.1080/15427560.2017.1331235

Chen, Y., Zhang, D., Wu, F., & Ji, Q. (2022). Climate risks and foreign direct investment in developing countries: the role of national governance. *Sustainability Science, 17*(5), 1723-1740. doi: https://doi.org/10.1007/s11625-022-01199-8

Creswell, J. W., & Creswell, J. (2003). *Research design*. Sage publications Thousand Oaks, CA.

D'Amato, A., Mazzanti, M., Nicolli, F., & Zoli, M. (2018). Illegal waste disposal: Enforcement actions and decentralized environmental policy. *Socio-Economic Planning Sciences, 64*, 56-65. doi: https://doi.org/10.1016/j.seps.2017.12.006

De Blust, G., Paelinckx, D., & Kuijken, E. (1994). Up-to-date information on nature quality for environmental management in Flanders. In *Ecosystem classification for environmental management* (pp. 223-249). Springer. doi: https://doi.org/10.1007/978-94-017-1384-9

Dimitrov, D. V. (2016). Medical internet of things and big data in healthcare. *Healthcare informatics research, 22*(3), 156-163. doi: https://doi.org/10.4258/hir.2016.22.3.156

Doshi, A. R., Dowell, G. W., & Toffel, M. W. (2013). How firms respond to mandatory information disclosure. *Strategic Management Journal, 34*(10), 1209-1231. doi: https://doi.org/10.1002/smj.2055

Earnhart, D., Harrington, D. R., & Glicksman, R. (2020). The effects of enforcement on corporate environmental performance: The role of perceived fairness. *Review of Law & Economics, 17*(1), 71-118. doi: https://doi.org/10.1515/rle-2019-0012

Ekata, G. E. (2012). The IT productivity paradox: Evidence from the Nigerian banking industry. *The Electronic Journal of Information Systems in Developing Countries, 51*(1), 1-25. doi: https://doi.org/10.1002/j.1681-4835.2012.tb00361.x

Esposito, P., Braga, A., Sancino, A., & Ricci, P. (2023). The strategic governance of the digital accounting environment: insights from virtual museums. *Meditari Accountancy Research, 31*(2), 366-380. doi: https://doi.org/10.1108/MEDAR-03-2020-0837

Evans, J. P. (2012). *Environmental governance*. Routledge. doi: https://doi.org/10.4324/9780203155677

Fang, Y., Perc, M., & Zhang, H. (2022). A game theoretical model for the stimulation of public cooperation in environmental collaborative governance. *Royal Society Open Science, 9*(11), 221148. doi: https://doi.org/10.1098/rsos.221148

Filgueiras, F., Almeida, V., Filgueiras, F., & Almeida, V. (2021). The digital world and governance structures. In *Governance for the Digital World: Neither More State nor More Market* (pp. 7-42). Palgrave Macmillan, Cham. doi: https://doi.org/10.1007/978-3-030-55248-0_2

George, G., & Schillebeeckx, S. J. (2022). Digital transformation, sustainability, and purpose in the multinational enterprise. *Journal of World Business, 57*(3), 101326. doi: https://doi.org/10.1016/j.jwb.2022.101326

Gill, A., & Mathur, N. (2011). Board size, CEO duality, and the value of Canadian manufacturing firms. *Journal of Applied Finance and Banking, 1*(3), 1-13. Retrieved from http://www.scienpress.com/Upload/JAFB/Vol%201_3_1.pdf

Goodman, M. K., Littler, J., Brockington, D., & Boykoff, M. (2016). Spectacular environmentalisms: Media, knowledge and the framing of ecological politics. *Environmental Communication, 10*(6), 677-688. doi: https://doi.org/10.1080/17524032.2016.1219489

Guimarães, E. F., & Rover, S. (2022). Uniformity and comparability: an analysis of the relevance for the Brazilian capital market. *Revista Contabilidade & Finanças, 33*, 265-280. doi: https://doi.org/10.1590/1808-057x202112890

Hermes, S., Riasanow, T., Clemons, E. K., Böhm, M., & Krcmar, H. (2020). The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. *Business Research, 13*, 1033-1069. doi: https://doi.org/10.1007/s40685-020-00125-x

Hinings, B., Gegenhuber, T., & Greenwood, R. (2018). Digital innovation and transformation: An institutional perspective. *Information and Organization, 28*(1), 52-61. doi: https://doi.org/10.1016/j.infoandorg.2018.02.004

Jovanović, M., Dlačić, J., & Okanović, M. (2018). Digitalization and society's sustainable development–Measures and implications. *Zbornik radova Ekonomskog fakulteta u Rijeci: časopis za ekonomsku teoriju i praksu, 36*(2), 905-928. doi: https://doi.org/10.18045/zbefri.2018.2.905

Karthiga, R., Keerthiga, B., & Preethi, S. (2019). Analysis on Machine Learning Techniques. *i-Manager's Journal on Computer Science, 7*(3), 46-50. doi: https://doi.org/10.26634/jcom.7.3.16739

Kim, S., Kraft, P., & Ryan, S. G. (2013). Financial statement comparability and credit risk. *Review of Accounting Studies, 18*, 783-823. doi: https://doi.org/10.1007/s11142-013-9233-z

Kloppenburg, S., Gupta, A., Kruk, S. R., Makris, S., Bergsvik, R., Korenhof, P., et al. (2022). Scrutinizing environmental governance in a digital age: New ways of seeing, participating, and intervening. *One Earth, 5*(3), 232-241. doi: https://doi.org/10.1016/j.oneear.2022.02.004

Kothari, S. P., So, E., & Verdi, R. (2016). Analysts' forecasts and asset pricing: A survey. *Annual Review of Financial Economics, 8*, 197-219. doi: https://doi.org/10.1146/annurev-financial-121415-032930

Kraus, S., Rehman, S. U., & García, F. J. S. (2020). Corporate social responsibility and environmental performance: The mediating role of environmental strategy and green innovation. *Technological forecasting and social change, 160*, 120262. doi: https://doi.org/10.1016/j.techfore.2020.120262

Kruk, S. R., Kloppenburg, S., Toonen, H. M., & Bush, S. R. (2021). Digitalizing environmental governance for smallholder participation in food systems. *Earth system governance, 10*, 100125. doi: https://doi.org/10.1016/j.esg.2021.100125

Kun, Q., & Nan, Y. X. (2021). Study on "Internet+" intelligent environmental protection to promote the modernization of environmental governance in Liaoning Province. *E3S Web of Conferences, 261*, 04025. doi: https://doi.org/10.1051/e3sconf/202126104025

Laari, S., Töyli, J., Solakivi, T., & Ojala, L. (2016). Firm performance and customer-driven green supply chain management. *Journal of cleaner production, 112*, 1960-1970. doi: https://doi.org/10.1016/j.jclepro.2015.06.150

Lee-Geiller, S., & Lee, T. (2022). How does digital governance contribute to effective crisis management? A case study of Korea's response to COVID-19. *Public Performance & Management Review, 45*(4), 860-893. doi: https://doi.org/10.1080/15309576.2022.2054434

Lei, Z., Huang, L., & Cai, Y. (2022). Can environmental tax bring strong porter effect? Evidence from Chinese Listed Companies. *Environmental Science and Pollution Research, 29*, 1-15. doi: https://doi.org/10.1007/s11356-021-17119-9

Li, H.-l., Zhu, X.-h., Chen, J.-y., & Jiang, F.-t. (2019a). Environmental regulations, environmental governance efficiency and the green transformation of China's iron and steel enterprises. *Ecological economics, 165*, 106397. doi: https://doi.org/10.1016/j.ecolecon.2019.106397

Li, P., & Guo, T. (2022). Is digital finance a powerful means for Chinese cities to reduce environmental pollution in the fourth industrial revolution? *Technology Analysis & Strategic Management*, 1-20. doi: https://doi.org/10.1080/09537325.2022.2137398

Li, Z., Shao, S., Shi, X., Sun, Y., & Zhang, X. (2019b). Structural transformation of manufacturing, natural resource dependence, and carbon emissions reduction: Evidence of a threshold effect from China. *Journal of cleaner production, 206*, 920-927. doi: https://doi.org/10.1016/j.jclepro.2018.09.241

Lin, B., & Xu, C. (2022). Does environmental decentralization aggravate pollution emissions? Microscopic evidence from Chinese industrial enterprises. *Science of the Total Environment, 829*, 154640. doi: https://doi.org/10.1016/j.scitotenv.2022.154640

Logg, J. M., Minson, J. A., & Moore, D. A. (2019). Algorithm appreciation: People prefer algorithmic to human judgment. *Organizational Behavior and Human Decision Processes, 151*, 90-103. doi: https://doi.org/10.1016/j.obhdp.2018.12.005

Lucatello, S., & Leconte, A. (2021). Complex Systems, Fragility and Security: Challenges for the EU Governance and Its Global Partners in Climate Change and Digitalization. *L'Europe en formation*, (2), 188-205. doi: https://doi.org/10.3917/eufor.393.0188

Luo, J., & Wu, Y. (2021). Level of digital operation and real earnings management. *J. Manag. Sci, 34*, 3-18.

Magazzino, C., & Mele, M. (2021). On the relationship between transportation infrastructure and economic development in China. *Research in Transportation Economics, 88*, 100947. doi: https://doi.org/10.1016/j.retrec.2020.100947

Magazzino, C., Mele, M., & Schneider, N. (2021). A machine learning approach on the relationship among solar and wind energy production, coal consumption, GDP, and CO2 emissions. *Renewable Energy, 167*, 99-115. doi: https://doi.org/10.1016/j.renene.2020.11.050

Mele, M., & Magazzino, C. (2020). A machine learning analysis of the relationship among iron and steel industries, air pollution, and economic growth in China. *Journal of cleaner production, 277*, 123293. doi: https://doi.org/10.1016/j.jclepro.2020.123293

Mohd Amin, S. I., & Abdul-Rahman, A. (2020). The role of regulation in Banking: Liquidity risk perspective. *Iranian Journal of Management Studies, 13*(3), 391-412. doi: https://doi.org/10.22059/ijms.2019.280790.673627

Nadkarni, S., & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly, 71*, 233-341. doi: https://doi.org/10.1007/s11301-020-00185-7

Nègre, E., Verdier, M.-A., Cho, C. H., & Patten, D. M. (2017). Disclosure strategies and investor reactions to downsizing announcements: A legitimacy perspective. *Journal of Accounting and Public Policy, 36*(3), 239-257. doi: https://doi.org/10.1016/j.jaccpubpol.2017.03.003

O'Flynn, J. (2021). Where to for public value? Taking stock and moving on. *International Journal of Public Administration, 44*(10), 867-877. doi: https://doi.org/10.1080/01900692.2021.1884696

Oliveira, M. C., & Siqueira, L. (2022). Digitalization between environmental activism and counter-activism: The case of satellite data on deforestation in the Brazilian Amazon. *Earth system governance, 12*, 100135. doi: https://doi.org/10.1016/j.esg.2022.100135

Prechel, H. (2021). Management, corporate form, and the financial social structure of accumulation. In *Handbook on Social Structure of Accumulation Theory* (pp. 327-342). Edward Elgar Publishing.

Prieto, L. C., Phipps, S. T., & Addae, I. Y. (2014). Is Wal-Mart a social enterprise? An exploration of the relationship between corporate reputation, corporate social responsibility & financial performance. *Academy of Strategic Management Journal, 13*(2), 51-60. Retrieved from https://www.proquest.com/openview/f4ae92222d1418f63fab0db8570e3c01

Rechner, P. L., & Dalton, D. R. (1991). CEO duality and organizational performance: A longitudinal analysis. *Strategic Management Journal, 12*(2), 155-160. doi: https://doi.org/10.1002/smj.4250120206

Ren, S., Hao, Y., & Wu, H. (2023). Digitalization and environment governance: does internet development reduce environmental pollution? *Journal of Environmental Planning and Management, 66*(7), 1533-1562. doi: https://doi.org/10.1080/09640568.2022.2033959

Schinagl, S., & Shahim, A. (2020). What do we know about information security governance? "From the basement to the boardroom": towards digital security governance. *Information & Computer Security, 28*(2), 261-292. doi: https://doi.org/10.1108/ICS-02-2019-0033

Shen, L., Zhang, X., & Liu, H. (2022). Digital technology adoption, digital dynamic capability, and digital transformation performance of textile industry: Moderating role of digital innovation orientation. *Managerial and Decision Economics, 43*(6), 2038-2054. doi: https://doi.org/10.1002/mde.3507

Shive, S. A., & Forster, M. M. (2020). Corporate governance and pollution externalities of public and private firms. *The Review of Financial Studies, 33*(3), 1296-1330. doi: https://doi.org/10.1093/rfs/hhz079

Singh, A., & Hess, T. (2020). How Chief Digital Officers Promote the Digital Transformation of their Companies. In *Strategic Information Management* (pp. 202-220). Routledge. doi: https://doi.org/10.4324/9780429286797-9

Siryk, Z., Popadynets, N., Pityulych, M., Chakii, O., Irtyshcheva, I., Panukhnyk, O., et al. (2021). Decentralization of local self-government under the conditions of administrative-territorial reform in Ukraine. *Accounting, 7*(4), 781-790. doi: http://dx.doi.org/10.5267/j.ac.2021.2.006

Skog, D. A., Wimelius, H., & Sandberg, J. (2018). Digital disruption. *Business & Information Systems Engineering, 60*, 431-437. doi: https://doi.org/10.1007/s12599-018-0550-4

Strycharz, J., Strauss, N., & Trilling, D. (2018). The role of media coverage in explaining stock market fluctuations: Insights for strategic financial communication. *International Journal of Strategic Communication, 12*(1), 67-85. doi: https://doi.org/10.1080/1553118X.2017.1378220

Tassabehji, R., Hackney, R., & Popovič, A. (2016). Emergent digital era governance: Enacting the role of the 'institutional entrepreneur'in transformational change. *Government Information Quarterly, 33*(2), 223-236. doi: https://doi.org/10.1016/j.giq.2016.04.003

Udemba, E. N., Magazzino, C., & Bekun, F. V. (2020). Modeling the nexus between pollutant emission, energy consumption, foreign direct investment, and economic growth: new insights from China. *Environmental Science and Pollution Research, 27*(15), 17831-17842. doi: https://doi.org/10.1007/s11356-020-08180-x

Wan, Q., Yuan, L., Yao, Z., & Zeng, L. (2023). The impact of R & D elements flow and government intervention on China's hi-tech industry innovation ability. *Technology Analysis & Strategic Management, 35*(7), 857-874. doi: https://doi.org/10.1080/09537325.2021.1988554

Wang, M., Zhou, Z., & Xu, C. (2018). Can Bank Debt Governance and Internal Governance Promote Enterprise Innovation? *Procedia computer science, 139*, 9-16. doi: https://doi.org/10.1016/j.procs.2018.10.211

Wen, H., Wen, C., & Lee, C.-C. (2022). Impact of digitalization and environmental regulation on total factor productivity. *Information Economics and Policy, 61*, 101007. doi: https://doi.org/10.1016/j.infoecopol.2022.101007

Xu, C., Chen, X., & Dai, W. (2022). Effects of Digital Transformation on Environmental Governance of Mining Enterprises: Evidence from China. *International Journal of Environmental Research and Public Health, 19*(24), 16474. doi: https://doi.org/10.3390/ijerph192416474

Xu, L., Chen, L., Zhang, S.-x., & Liu, N. (2018). Tone at the top management, media attention and environmental performance. *East China Econ. Manag, 32*, 114-123.

Yan, S., Almandoz, J., & Ferraro, F. (2021). The impact of logic (in) compatibility: Green investing, state policy, and corporate environmental performance. *Administrative Science Quarterly, 66*(4), 903-944. doi: https://doi.org/10.1177/00018392211005756

Yeow, A., Soh, C., & Hansen, R. (2018). Aligning with new digital strategy: A dynamic capabilities approach. *The Journal of Strategic Information Systems, 27*(1), 43-58. doi: https://doi.org/10.1016/j.jsis.2017.09.001

Zhang, B., Dong, W., & Yao, J. (2022). How Does Digital Transformation of City Governance Affect Environmental Pollution: A Natural Experiment from the Pilot Policy of "National Information City for Public Service" in China. *Sustainability, 14*(21), 14158. doi: https://doi.org/10.3390/su142114158

Ziyadin, S., Suieubayeva, S., & Utegenova, A. (2020). Digital transformation in business. In *Digital Age: Chances, Challenges and Future 7* (pp. 408-415). Springer. doi: https://doi.org/10.1007/978-3-030-27015-5_49