## Digital Transformation and Sustainable development in US companies

Laura Pellegrini<sup>1</sup>, Luca Giorgi<sup>2</sup>

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## ABSTRACT

In the middle of the rapid development of digital technologies and constant change, digital transformation has become a strategic choice that companies must adopt to remain competitive. Digital transformation enables companies to reduce operating costs, improve productivity, develop new products, and meet modern customer demands. Beyond financial value, digital transformation may enhance corporate sustainability performance. The paper explores the impact of digital transformation on corporate ESG performance in US framework. Using FE models on a sample of 254 companies belonging to the S&P500 from 2015 to 2022, the results show positive impacts of digital transformation on ESG performance. The study point out that firms able to carrying out digital transformation may improve sustainability performances. The analysis revealed that the positive impact of digital transformation on ESG performances is more significant in companies with greater proportion of Indipendent Directors and show negative relationship with cases in which the CEO is also the Chair of the Board of Directors.

## Keywords

Digital Transformation, ESG Performance, Independent Directors, CEO duality, Governance issues.

<sup>&</sup>lt;sup>1</sup> Department of Management, University of Bergamo, Bergamo, Italy.

<sup>&</sup>lt;sup>2</sup> Catholic University of the Sacred Heart, Milan, Italy.

## 1. Introduction

In recent economic and business context, a combination of global factors such as climate change, pollution, economic and social inequalities, human rights, and corruption has brought ESG issues to the forefront. Corporate sustainability has become an increasingly significant topic in the global economic landscape. This has led companies to revise their strategies to integrate sustainable and responsible practices. Once purely economic actors, companies are now recognized as key agents for promoting sustainable development. While focusing on their financial performance, businesses must also assume environmental, social, and corporate governance responsibilities to contribute to building an economy that promotes high-quality development overall.

Companies are increasingly recognizing that integrating ESG criteria into their business models can lead to improved operational efficiency and financial performance, reduced reputational risks, and greater appeal to investors. Sustainability is currently a key driver in new business models for companies and the entire ecosystem surrounding them. It fosters innovation, creates new business opportunities, and reduces exposure to climate, environmental, and reputational risks, providing concrete benefits and creating long-term value (Bellavite Pellegrini at al., 2022). By increasingly integrated sustainable corporate strategies, companies may enhance differentiation from competitors and gain competitive advantages in terms of innovation, market penetration, client branding, and community development (Wang et al., 2023). At the same time, the rapid and constant advancement of digital technologies such as artificial intelligence, big data, blockchain, and cloud computing is strongly transforming how companies operate and compete in global markets (Fang et al., 2023; Lu et al. 2023).

Within the recent academic and entrepreneurial sphere, numerous questions are being explored, especially concerning the renewal of business models and strategies needed to fully harness the potential benefits offered by digital technologies and its transformation. This concept embodies a profound and revolutionary process of change that is impacting companies across every industry. On the one hand, digital transformation opens new opportunities for companies, such as adopting new business models, continuously launching new products or services, and fostering innovative forms of customer engagement. On the other hand, it involves the efforts of established companies to evolve and align with digital trends (Crupi and Marozzo, 2023). Therefore, digital transformation is no longer merely an option; it has become a mandatory choice for businesses aiming to innovate and improve their competitiveness, profitability, to facilitate access to new markets, and simplify corporate management (Liu and Liu, 2023). Based on the above, companies are facing increasing competitive pressure driven both by the transition toward new sustainable models and the acceleration of progress in digital technologies. In this context, the relationship between digital transformation and a company's ESG performance is particularly intriguing but interconnected (Cai et al., 2023; Yang et al., 2023). For a long time, corporate sustainability was mistakenly perceived by many companies as merely a financial burden or even a hindrance to business and economic returns. However, in the current contest, thanks to the relevant potential offered by digital technologies, sustainability can represent a fundamental strategic and competitive factor for businesses (Ren et al., 2023; Rush et al., 2023; Wen, Zong and Lee, 2022).

This paper explores the relationship between the level of digital transformation and the ESG performance of companies by analyzing how and to what extent the adoption of digital technologies can affect corporate sustainability. The analysis is based on balanced data from a sample of 254 US

public companies in the S&P500, spanning the period of 2015 to 2022. The research aims to contribute to existing literature on the subject in two keyways. On the one hand it expands research on the economic implications of digital transformation in firms. While prior studies have predominantly focused on how digital transformation affects financial performance, few have investigated its impact on non-financial performance. This paper addresses this gap by specifically exploring the relationship between digital transformation and corporate ESG performance. On the other hand, it enriches the empirical literature on this topic mainly focused on Asian Context and neglecting other regions.

The structure of this paper is as follows: Section 2 includes a comprehensive review of the existing literature on the relationship between digital transformation and sustainability performance and presents the research hypotheses. Section 3 introduces data, variables, and the empirical models used to test the hypotheses. Section 4 presents the baseline results, along with some robustness tests with control variables to ensure the validity of the findings. Finally, Section 5 concludes the study, offering practical recommendations, academic insights, and discussing the limitations of the research, which provide directions for future investigations.

## 2. Theoretical analysis and hypothesis development

Digital transformation has become a strategy in management processes that companies must necessarily undertake to adapt to current trends and pursue their long-term development, supporting business, increasing transparency and sharing of information and thus reducing agency costs (Cai et al., 2023). Digital transformation refers to the process through which companies deeply integrate digital technologies into their business processes, bringing significant changes to production processes, organizational structure, research and development activities, and overall business models. The numerous applications, potential uses, and benefits of digital technologies such as the Internet of Things, big data, artificial intelligence, and blockchain have garnered significant interest among academic researchers and practitioners, driving them to investigate the impact of these technologies across various levels and sectors. Specifically, concerning companies, various studies have provided extensive analyses of the value creation effects of digital transformation (Yang et al., 2023). Wen et al. (2022) demonstrated that digital transformation fosters corporate innovation. Based on data from publicly listed Chinese manufacturing companies, their study examines the link between the digitalization of the manufacturing industry and investments in corporate innovation: empirical evidence indicates that manufacturing companies significantly increased their investments in innovation activities as part of the digital transformation process. Gaglio et al. (2022), through an analysis of small and medium-sized manufacturing enterprises in South Africa, showed that digital transformation has a positive effect on innovation, which in turn positively impacts corporate productivity. Within literature, a specific field of research has been dedicated to investigating the relationship between digital transformation and companies' financial performance. Numerous studies have examined how digital transformation affects revenues, operating costs, profitability, and market value. Overall, various empirical studies suggest that digital transformation plays a vital role and has the potential features to improve companies' financial performance and market value through a wide range of channels, such as enhancing efficiency, increasing productivity, and improving decisionmaking processes (Jardak and Salah, 2022; Zeng et al., 2022; Guo and Xu, 2021).

Relatively few investigations have instead examined the relationship between digital transformation and the non-financial performance of companies. So far, few studies have paid attention to the connection between corporate digital transformation and ESG performance. The direction of influence and the internal mechanism linking these two concepts remain largely unexplored. In other words, it is still not fully understood whether, how, and to what extent corporate digital transformation impacts environmental, social, and governance performance, as well as the specific processes through which this influence manifests (Yang et al., 2023).

Only recently scholars started to investigate the relationship between digital transformation and corporate ESG performance. Research conducted has led to two main categories of findings: the "empowerment" effect and the "too much is not good" effect. The "empowerment" effect is specifically reflected in the fact that digital transformation can enhance ESG performance by reducing agency costs, improving corporate reputation, and strengthening dynamic capabilities with interesting positive impact of corporate governance. Digital transformation allows for the collection and processing of vast amounts of real-time data. The use of advanced data analysis techniques supports strategic decision-making, enabling companies to make decisions based on clear and accurate information. Predictive analytics tools help companies streamline operational processes, anticipate trends, identify potential risks, and make informed decisions to mitigate them. As a result, businesses may adapt more effectively to market uncertainties through digital technologies. Additionally, digital transformation helps reduce informational asymmetries between different departments within a company and external stakeholders, improving transparency and ensuring more effective internal and external oversight of business operations. These factors enhance corporate governance, making it more responsive, efficient, and transparent. (Hacioglu and Aksoy, 2021).

The "too much is not good" effect reflects the idea that an excessive level of digitalization can weaken managers' ability and motivation to adopt socially responsible practices. Additionally, asymmetric digital transformation, understood as uneven adoption of digital technologies within a company, and the organizational transformation process, which involves the structural and cultural changes necessary to effectively integrate new digital technologies, may hinder the realization of the enabling effect of digital technology. Specifically, suboptimal management of the digital transformation process could lead to information overload, thereby reducing companies' ability to process this information. Furthermore, significant capital investment in digital technology implementation may generate the so-called "crowding-out effect," whereby investing substantial resources in the digital transformation process diverts financial and human resources away from environmental sustainability practices, thereby delaying the company's green transformation process (Wu et al., 2024).

Delving into the empowerment effect, digital transformation seems to highlight a positive impact on the ESG performance of companies, with several studies showing its benefits through various channels. Su et al. (2023), point out that digital technological innovation can improve ESG performance through dynamic capabilities such as green innovation, social responsibility, and operational management. Cai et al. (2023) emphasize how the adoption of new digital technologies reduces information asymmetry, alleviates financing constraints, and promotes corporate transparency and better governance mechanism (see also Yang et al., 2023). Wu and Li (2023), in their study, observe that digital transformation helps reduce both internal and external information asymmetry, alleviates principal-agent conflicts, and fosters green innovation, thereby contributing to the improvement of ESG performance and corporate reputation (see also Fang et al. 2023). Further studies find that digitalization positively affects ESG performance thanks to main factors such as curbing managerial myopia, improving internal information transparency, and enhancing technological innovation within companies (Zhong et al. (2023) or through specific processes: optimizing the structure of human capital, improving operational and managerial efficiency, and promoting green innovation (Pen et al., 2023).

Based on the studies mentioned above, digital transformation offers companies many opportunities to promote corporate sustainability. However, some research shows that excessive and unbalanced adoption of new digital technologies can have negative effects on the ESG performance of companies: this is referred to as the "too much is not good" effect. When companies push too hard on digitalization without a well-thought-out and clearly defined strategy, significant problems can emerge that negatively impact their ESG performance. The intensive use of digital technologies can generate various issues, such as exponential growth in electronic waste, increased energy consumption and carbon emissions, depersonalization of work processes, reduced employee wellbeing, and the risk of exclusion for those lacking digital skills, as well as challenges related to data security, privacy, and regulatory compliance, which may undermine corporate reputation. In this regard, important studies by Yang and Han (2024) and Wang and Guo (2023) highlight that the impact of digital transformation on ESG performance follows an inverted U-shaped curve. Moderate digitalization improves ESG performance through better communication and internal information disclosure, enhanced green innovation capabilities, reduced information asymmetry, improved internal control capabilities, and reduced agency costs. However, excessive digitalization may reduce the enabling effect of digital technology and lead to new organizational management conflicts that undermine internal controls, significantly increase business costs, introduce new principal-agent issues, and ultimately negatively impact corporate ESG performance.

Companies are expected to pursue social responsibility toward all stakeholders they interact with (Freeman, 1984; Schoenmaker and Schramade, 2021, 2024). Implementing ESG practices can lead to certain side effects for companies, potentially limiting their investment in these initiatives. On the one hand, corporate investments in ESG initiatives may result in resource wastage, additional expenses, negative effects on the company, weakened competitiveness, and harm to shareholder interests. On the other hand, many companies lack sufficient capacity to manage such initiatives and must bear high costs to improve their ESG performance due to resource scarcity, limited technical means, and informational asymmetries, leading to insufficient incentives for ESG practices (Zhao and Cai, 2023). In this context, the digital transformation of businesses plays an increasingly crucial role as an important strategy for achieving high-quality corporate development in the new sustainable era. Considering the above analysis, the following hypothesis can be proposed:

H1: Corporate Digital transformation of businesses is positively associated with improvements in ESG performance.

*H2: Digital transformation contributes to ESG performance by improving profitability, together with interesting governance features.* 

H3: The impact of digital transformation on sustainability performance points out heterogeneity across pillar, with positive impact on governance quality.

## 3. Research Design

## 3.1 Samples and Data Source

The study focuses on balanced panel data of a sample of listed companies in the S&P 500, covering the period from 2015 to 2022. Most of the existing literature on the subject focuses on publicly traded Chinese companies, analyzing a specific regulatory and cultural context characterized by extraordinary economic growth and, in recent years, by a rapid adoption of digital technologies, particularly under the "Made in China 2025" program<sup>3</sup>. In contrast, this study aims to analyze a mature market. Specifically, the research sample consists of companies belonging to the S&P 500, as global leaders operating in international markets. Analyzing these companies provides a broader and more diversified perspective compared to studies focusing on Chinese companies, leading to more generalizable results that could be applicable to other Western economies, such as those in Europe.

The final sample selection was conducted through a multi-step process: (1) we excluded at first the financial sector due to different features compared to companies in other sectors. Differences in Regulations, business models, and ESG performance metrics could distort the research findings. (2) we consider balanced data panel; (3) we eliminate companies with excessive missing data.

Following this process, the final sample consists of 254 companies belonging to the S&P 500 over the 2015–2022 period, resulting in a total of 2,032 observations for the subsequent empirical analysis. The data were sourced from the LSEG DataStream database<sup>4</sup> and the EDGAR database managed by the U.S. Securities and Exchange Commission (SEC). The study proposes two models: (1) the baseline regression, where we investigate the impact of the digital transformation ("DT") on the overall ESG company performance and the second one (2) which studies the effect of DT over each single pillar ("E", "S" and "G").

## 3.2 Variables

## **Dependent** Variable

The dependent variable of this analysis is firm ESG performance (named "ESG score"), obtained from LSEG DataStream database. LSEG's ESG scores provide a clear and transparent assessment of companies' relative ESG performance across ten key themes (concerning emissions, environmental product innovation, human rights, shareholders), integrating and accounting for sector-specific characteristics and company size biases. It consolidates and processes over 630 corporate ESG indicators, of which a subset of 186, deemed the most comparable and relevant for each sector, feeds into the overall scoring and evaluation process. The underlying measures are built on considerations of comparability, impact, data availability, and sector relevance, which vary depending on the industry group.

The overall ESG score reflects the company's ESG performance, commitment, and effectiveness based on publicly disclosed information. The overall ESG score can be divided into three main pillars: the environmental pillar ("E" score), the social pillar ("S" score), and the corporate governance pillar

<sup>&</sup>lt;sup>3</sup> Launched in 2015, this program aims to transform the People's Republic of China from the "world's factory" into a "mega Industry 4.0" hub within ten years.

<sup>&</sup>lt;sup>4</sup> Formerly Refinitiv Datastream.

("G" score). Each pillar represents a distinct area of a company's ESG performance. The overall ESG score is a relative sum of weights assigned to the various categories, which vary by sector for the environmental and social categories. The ESG scores are normalized into percentages ranging from 0 to 100 to facilitate interpretation.

## Core explanatory Variable

The core explanatory variable is represented by the level of digital transformation of the firms in the sample (DT). Constructing an indicator that can validly and effectively represent the level of digital transformation of firms is a complex issue in current research.

Recent literature identified four main methods for measuring the degree of digital transformation of firms. One first method involves constructing digital transformation dummy variables through manual collection of annual reports and corporate announcements (Zhao and Cai, 2023). However, the disadvantage of this method is that the dummy variables reflect the degree of digital transformation with wide margins of error. The second method is defined according to Jiang et al. (2022) who argued that the proportion of intangible digital assets relative to total assets represents a reliable economic proxy for the degree of digital transformation of firms. The downside of this approach is that it considers only capital expenditure and not operational expenses related to digital transformation. Thirdly, some studies have conducted surveys using questionnaires addressed to firms to construct an indicator reflecting their level of digital transformation of firms by constructing an indicator through textual analysis and statistical word frequency analysis of the words found in corporate annual reports (Zhang et al., 2024; Yang et al., 2023).

In keeping with the most recent studies, the present study also adopts this latter method (Zhang et al., 2024; Yang et al., 2023). The idea underlying this measurement method is that a company's annual report is not merely a summary of corporate management for the year; it serves as an objective statement based on the company's actual operations, reflecting its corporate philosophy, strategic characteristics, development path, and future prospects. Therefore, in general, the bigger the frequency with which words related to a specific type of event appear in the annual report, the greater the importance the company assigns to that event. In this specific case, the higher the frequency of words related to digital transformation in the annual report, the greater the importance attributed by the company to digital transformation itself.

In detail, the procedure used to construct the digital transformation indicator for companies consists of the following steps: Firstly, annual reports of the companies in the sample from 2015 to 2022 were downloaded from the EDGAR database managed by the United States Securities and Exchange Commission (SEC), and the text was extracted using RStudio, an integrated development environment for the R programming language. Subsequently, based on relevant academic articles and industry studies (Whang and Hou, 2024; Wang et al., 2023), a "digital" vocabulary was constructed, consisting of 102 keywords related to digital transformation (see Table A.1 in Appendix). The third step, also carried out using RStudio, involved extracting the frequency of individual keywords in the text of the annual reports. By summing the frequency of each keyword, the total frequency of keywords for each individual annual report as a proxy variable to measure the degree of digital transformation of a company. The keyword frequency counting method leads to final data

characterized by "right bias." This term refers to data that exhibits a right-skewed or positive distribution: most data is concentrated on the left side of the distribution, with a long tail extending to the right. In other words, most values are below the mean, with a few very high values stretching the tail to the right. Therefore, as the final step, to better handle this situation and make the distribution more symmetrical, 1 was added to the total frequency, and the natural logarithm was applied. This logarithmic transformation compresses the data scale, mitigating the influence of very high values, and thus normalizes the data.

## **Control Variables**

Based on relevant literature (Cai et al., 2023; Peng et al., 2023; Wang et al., 2023), this study selects the following control variable to enhance the robustness and reliability of the findings. Specifically, the following control variables, both financial and related to corporate governance features, were considered: firm listing age (*Age*), firm size (*Size*), Leverage (*Lev*), Return on Assets (*ROA*), proportion of Independent Directors (*Indep*), and CEO duality (*Duality*), and controls for the year effect (*Year*) and the industry effect (*Sector*).

*Firm Listing Age (Age):* This variable indicates how long a company has been publicly listed. In this study, this variable is measured by applying the natural logarithm to the number of years since the company's initial public offering (IPO). Companies that have been listed for a longer time are generally more stable and mature than those with more recent listings. These companies have had more time to adapt to market pressures, changes in sustainability regulations, and stakeholder expectations. This greater experience and maturity may influence their long-term perspective and, consequently, their ability to invest in and manage ESG practices effectively.

*Firm Size (Size):* This refers to the size of the company. In this study, this variable is measured by applying the natural logarithm to the company's total assets at the end of the year. Larger companies may face stricter regulations regarding sustainable practices than smaller ones due to their greater environmental and social impact. Larger companies also tend to attract more public attention and may therefore be more inclined to invest in sustainable practices to maintain a good reputation and meet stakeholder expectations. Furthermore, larger firms typically have more financial resources and thus may have larger budgets to allocate to ESG practices compared to smaller firms.

*Leverage (Lev):* This variable is calculated as the ratio of total debt to total assets at the end of the year. Companies with high financial leverage, and thus a significant debt burden, may reduce investments in ESG practices due to limited resources resulting from financial pressures to repay debt.

*Return on Assets (ROA):* This is a financial indicator that measures a company's profitability relative to the resources used to conduct its business. In this analysis, ROA is calculated as the ratio of net profit plus post-tax interest to average total assets. Companies with strong profitability are in a stable financial position and have sufficient resources and guarantees to invest in sustainable practices.

*Proportion of Independent Directors (Indep):* This variable expresses the proportion of independent directors on the Board of Directors (BoD). It is calculated as the ratio of the number of independent directors to the total size of the BoD. Independent directors are board members who are not involved in the company's day-to-day management and who do not have relationships with the company that could compromise their autonomy. They are expected to act as monitors and provide checks and balances against executive directors, ensuring that the interests of controlling shareholders do not

outweigh social interests. A BoD with a higher proportion of independent directors should generally be more effective in monitoring corporate practices, including ESG activities. This stems from independent directors offering objective and impartial perspectives, enhancing governance rigor, and promoting greater attention and transparency in sustainability practices, which might be overlooked if the BoD comprises mainly members with close ties to the company.

*CEO Duality (Duality):* CEO duality refers to the situation where the Chief Executive Officer also serves as the Chair of the BoD. This variable may be considered as a possible *proxy* of private benefits which affect agency costs. In this analysis, CEO duality is treated as a dummy variable, assigned a value of 1 if the CEO also holds the role of Chair and 0 otherwise. Such a situation could significantly affect corporate governance. When the CEO also chairs the BoD, there is a higher concentration of decision-making power in one individual, which could impact the importance given to ESG investments as decisions may be guided by personal interests. Conversely, separating the roles of CEO and Chair is considered good governance practice. In cases where the roles are separated, there is greater oversight and monitoring of the CEO by the BoD, potentially leading to more transparency and balanced ESG decisions.

## 3.3 Methodology

Based on the existing literature (Yang et al., 2023), to verify the hypothesis and to investigate the influence of corporate digital transformation on the ESG performance of the companies, the following baseline regression model has been developed:

$$ESG_{i,t} = \beta_0 + \beta_1 Digital_{i,t-1} + \beta_2 Controls_{i,t-1} + \sum Ind + \sum Year + \varepsilon$$
(1)

where *i* and *t* represent the company and the year, respectively. The dependent variable  $ESG_{i,t}$  represents the ESG performance of company *i* in year *t*. The main independent variable  $Digital_{i,t-1}$  represents the level of digital transformation of company *i* in year *t-1*.  $\beta_1$  represents the impact of the digital transformation of company *i* on its ESG performance in year *t-1*. Considering the possible problems of reverse causality on the regression results, the explanatory variable and control variables have lagged by one year. Lagging the variables helps reduce this effect by separating the temporal impacts and allowing for a clearer view of the causal relationship between the variables (Yang et al., 2023). The term  $Controls_{i,t-1}$  refers to all the control variables considered in the analysis, which may influence the dependent variable  $ESG_{i,t}$ : firm listing age (*Age*), firm size (*Size*), Leverage (*Lev*), Return on Assets (*ROA*), proportion of Independent Directors (*Indep*), and CEO duality (*Duality*). The model also accounts for individual fixed effects, by Industry (*Ind*) and temporal fixed effects, by year (*Year*) and includes the random error term  $\varepsilon_{i,t}$ .

## 4. Empirical Results and Analysis

### 4.1 Descriptive Statistics

Table 1 shows the descriptive statistics of the variables considered in the study. Regarding the *ESG* variable, the mean ESG score of the companies is 63.5442, indicating a generally good

environmental, social, and governance performance during the period under review. The minimum value is 5.8100, and the maximum value is 93.3900. This evidence implies effective commitment to sustainable and responsible business practices. We state some degree of volatility in the distribution of ESG scores, however, the distribution of ESG scores does not present critical anomalies. The level of digital transformation of the companies in the sample ranges from a minimum of 0.0000 to a maximum of 4.6540. The mean value, equal to 2.1630, suggests that companies, on average, have a moderate degree of digital transformation. The standard deviation of the *Digital* variable is 0.8014, indicating some variability in the level of digital transformation among companies, though not excessive. The median value of 2.1972 is very close to the mean. Based on these observations, it can be noted that the data distribution is symmetrical and that most companies have a level of digital transformation concentrated around values close to the mean, with no significant extreme deviations. The descriptive statistics of the financial indicators and other variables considered in the model are highly consistent with the findings reported in the existing literature.

Variable	Observations	Mean	SD	Min	Median	Max
ESG	2032	63,5442	15,8073	5,8100	66,5050	93,3900
E score	2032	58,8959	23,5525	0,0000	64,6500	98,0700
S score	2032	65,9911	19,1190	11,2100	68,2750	98,2600
G score	2032	63,6813	18,7585	5,1000	66,3550	99,4300
Digital	2032	2,1630	0,8014	0,0000	2,1972	4,6540
Age	2032	3,4589	0,7175	0,0000	3,4965	4,7536
Size	2032	16,7966	1,1441	13,5414	16,7370	20,1285
Lev	2032	0,3320	0,1389	0,0004	0,3313	0,9117
ROA	2032	0,0874	0,0661	-0,2299	0,0747	0,7061
Indep	2032	0,8514	0,0841	0,3750	0,8750	1,0000
Duality	2032	0,7116	0,4531	0,0000	1,0000	1,0000

Table 1: Descriptive statistics of key variables

Data sources: LSEG Datastream and EDGAR system

#### Source(s): Authors' work

Table 2 presents the average values and standard deviations of the *ESG* and *Digital* variables by year, from 2015 to 2022.

Table 2: Mean and standard deviation of ESG and Digital variables by year

	ES	G	Dig	ital
Year	Mean	SD	Mean	SD
2015	56,0	18,0	1,86	0,846
2016	58,9	17,0	2,02	0,819
2017	61,2	16,4	2,02	0,833

2018	62,7	15,8	2,07	0,800
2019	65,1	14,7	2,24	0,757
2020	67,1	14,2	2,30	0,753
2021	68,3	12,8	2,39	0,722
2022	69,0	11,9	2,41	0,700

Data sources: LSEG Datastream and EDGAR system

#### Source(s): Authors' work

The average values of ESG and Digital from Table 2 are graphically depicted in Figure 1 and Figure 2, respectively. Regarding the time trend of ESG performance among the companies in the sample (Figure 1), there is a generally positive trend indicating a growing commitment by companies to sustainable and responsible practices. This steady improvement in ESG performance likely reflects increasingly stringent regulatory pressures as well as heightened awareness among investors and consumers of practices that respect the environment and promote ethical corporate governance.





Data sources: LSEG Datastream and EDGAR system

#### Source(s): Authors' work

Similarly, the level of digital transformation among companies (Figure 2) has shown consistent growth over the observed period, rising from a value of 1.86 in 2015 to 2.41 in 2022. While the increase is not explosive, the gradual upward trend, particularly from 2019 onwards, demonstrates the relentless adoption of digital technologies by companies. This trend can be attributed to the rapid development of emerging technologies such as artificial intelligence, blockchain, and cloud computing, which have accelerated the process of digital transformation in companies, providing them with increasing opportunities to enhance operational efficiency and remain competitive in the global landscape.





Data sources: LSEG Datastream and EDGAR system

#### Source(s): Authors' work

Table 3 shows mean and standard deviation of ESG performance and the level of digital transformation across sectors. The average values of ESG performance are generally high, with slight variations between sectors. The highest average scores are observed in the consumer staples sector (68.6), healthcare sector (67.1), and information technology sector (66.6). In contrast, the communication services sector has the lowest average ESG score (51.5). Particularly noteworthy is the average ESG score of companies in the energy sector. The energy sector faces significant challenges, particularly in terms of environmental sustainability, yet its intermediate score (61.9) suggests that companies in this sector have made considerable efforts to adopt more sustainable and responsible practices, even though there is still room for improvement. Regarding the averages values of digital transformation level, the information technology sector has the highest level, with an average of 2.64. This is expected, as technology companies in the S&P 500 are global leaders in digital innovation. Companies in the consumer discretionary and consumer staples sectors also exhibit high levels of digital transformation. Conversely, the energy sector has the lowest level of digitalization. Energy companies, being traditional and less inclined to change, often perceive the innovations of other sectors as difficult to apply to their reality.

	ESG		Dig	ital
Sector	Mean	SD	Mean	SD
Communication Services	51,5	18,8	1,99	0,520
Consumer Discretionary	56,1	18,5	2,52	0,918
Consumer Staples	68,6	12,8	2,47	0,807
Energy	61,9	17,6	1,44	0,700
Health Care	67,1	15,4	2,18	0,663
Industrials	60,2	15,5	2,18	0,754
Information Technology	66,6	13,9	2,64	0,702

Table 3: Mean and standard deviation of ESG e Digital variables by sector

Materials	65,6	13,4	1,61	0,624
Real Estate	65,3	16,3	1,75	0,766
Utilities	63,6	13,2	1,88	0,659

Data sources: LSEG Datastream and EDGAR system

#### Source(s): Authors' work

## 4.2 Correlation Analysis and Collinearity Diagnosis

To ensure robustness and reliability of the research we performed correlation analysis and multicollinearity diagnostics. We test for Pearson correlation coefficients and their statistical significance (see Table A.2 in Appendix). We detected positive and statistically significant correlation between the digital transformation index and the variable related to ESG performance, suggesting that the degree of digital transformation in companies may positively affect their ESG performance. We test for multicollinearity also, using Variance Inflation Factor measure (VIF). The analysis underlines no multicollinearity issues among the independent variables considered in the model. Column (2) also reports the level of tolerance, revealing minimal influences across the explanatory variables (see Table A.3 in Appendix).

### 4.3 The Impact of Digital Transformation on ESG Performance: Output Regression and Results

To evaluate the impact of digital transformation (*Digital*) on companies' ESG performance, a stepwise regression strategy was adopted, introducing control and other explanatory variables progressively to enhance robustness. The first step considers a simple model that allows for observing the isolated, or raw, effect of companies' digital transformation levels on their ESG performance.

For each step, we present OLS regression, RE and FE models. The results for each step are reported in Tables 4, 5, 6 and 7. Empirical findings highlight a positive and significant effect of digital transformation on companies' ESG performance, with some differences according to model estimated. We test for suitable models through the F-test, the Breusch-Pagan Lagrange Multiplier test, and the Hausman test. The tests are mostly in favor of FE model. The simplest regression model and results are reported in Table 4. The results of this model demonstrate that the level of digital transformation has a positive and significant effect at the 1% level on companies' ESG performance: the higher the degree of digital transformation, the better the ESG performance. The size of R<sup>2</sup> indicates that there are additional variables not considered in this model that influence companies' ESG performance.

		Dependent Variable					
		ESG					
	(1)	(2)	(3)				
	OLS	RE	FE				
Digital	$0.040^{***}$	$0.022^{***}$	0.019**				
Digitat	(0.008)	(0.008)	(0.009)				

Table 4: The impact of digital transformation on ESG performance, first step.

Age

Size			
Lev			
ROA			
Indep			
Duality			
Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,778	1,778	1,778
$\mathbb{R}^2$	0.013	0.004	0.013

Notes: \*p<0.1, \*\*p<0.05, \*\*\*p<0.01; standard errors in parentheses.

#### Source(s): Authors' work

Table 5 reports the regression results after adding the control variables *Age*, *Size*, *Lev* to the baseline regression model. The coefficient for the level of digital transformation, equal to 0.016, is significant at the 10% level (FE model). This demonstrates a positive relationship between the level of digital transformation and companies' ESG performance. The variable *Age* has a coefficient of 0.173, significant at the 1% level. This suggests that companies listed on the stock exchange for more years tend to have better ESG performance: they are more stable and mature, which could enable them to implement more effective ESG practices. Similarly, *Size* has a positive coefficient of 0.059, significantly at the 1% level. Stricter regulations, greater visibility, and the need to maintain a good reputation, along with broader financial resources, might be some of the factors explaining why larger companies tend to have better ESG performance compared to smaller ones. The variable *Lev*, which measures the level of corporate debt, has a negative coefficient of -0.097, significant at the 10% level. This indicates that a higher level of financial leverage corresponds to lower ESG performance. Due to the pressure to repay debt, companies may have fewer resources available for sustainable initiatives.

		Dependent Variable	
		ESG	
	(1)	(2)	(3)
	OLS	RE	FE
Digital	0.036***	$0.020^{**}$	$0.016^{*}$
	(0.007)	(0.008)	(0.009)
Age	$0.067^{***}$	$0.096^{***}$	$0.173^{***}$
	(0.009)	(0.017)	(0.030)
Size	$0.076^{***}$	$0.069^{***}$	$0.059^{***}$
	(0.006)	(0.010)	(0.015)
Lev	-0.015	-0.087*	$-0.097^{*}$
	(0.044)	(0.051)	(0.058)
ROA			
Indep			

Table 5: The impact of digital transformation on ESG performance, second step.

Duality			
Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,778	1,778	1,778
$\mathbb{R}^2$	0.175	0.063	0.141

Notes: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01; standard errors in parentheses.

#### Source(s): Authors' work

In the third step of the analysis, we introduce ROA as *proxy* of profitability and efficiency in utilizing assets to generate profits. These factors can directly influence a company's ability to invest in ESG practices. The results are presented in Table 6. The coefficients for the variables *Digital*, *Age*, and *Size* show quite similar values from previous analysis with the same level of significance, except for Leverage one. Regarding the added variable, it can be observed that *ROA* has a coefficient of 0.143, with a positive and significant impact at the 10% level on companies' ESG performance. This highlights that companies with higher profitability and accounting performance tend to have higher ESG scores: such companies may have greater resources to allocate investments in sustainable practices (Bellavite Pellegrini, et al, 2022). The R<sup>2</sup> coefficient improved (around 15%).

		Dependent Variable			
	ESG				
	(1)	(2)	(3)		
	OLS	RE	FE		
Digital	$0.031^{***}$ (0.008)	$0.020^{**}$ (0.008)	$0.016^{*}$ (0.009)		
Age	$0.066^{***}$ (0.009)	$0.096^{***}$ (0.017)	$0.175^{***}$ (0.030)		
Size	0.081 <sup>***</sup> (0.006)	$0.071^{***}$ (0.010)	$0.060^{***}$ (0.015)		
Lev	0.007 (0.045)	-0.067 (0.052)	-0.077 (0.059)		
ROA	0.339*** (0.098)	0.162** (0.072)	$0.143^{*}$ (0.074)		
Indep					
Duality					
Ind	Yes	Yes	Yes		
Year	Yes	Yes	Yes		
Observations	1,778	1,778	1,778		
$\mathbb{R}^2$	0.180	0.066	0.143		

Table 6: The impact of digital transformation on ESG performance, third step.

Notes: p < 0.1; p < 0.05; p < 0.01; standard errors in parentheses.

Source(s): Authors' work

In the fourth and final step, two variables reflecting significant governance characteristics of companies were added to the model (Wang et al., 2023): the percentage of independent directors on the Board of Directors (*Indep*) and CEO duality (*Duality*). The results are reported in Table 7.

Firstly, it can be observed that the coefficient for the level of companies' digital transformation is positive and statistically significant. Regarding most control variables we highlight a positive and significant impact at the 1% level on companies' ESG performance and ROA also has a positive impact with a good level of significance. This implies that more mature companies, those with greater visibility and thus more exposed to stakeholder pressures, those with extensive financial resources, and those with boards composed of many independent directors – who can make decisions in the interests of all stakeholders involved - tend to have better ESG performance than companies lacking these characteristics. The variables related to leverage (Lev) and the presence of a single person holding both the CEO and Board Chair positions (Duality) have negative coefficients in part statistically significant. Companies with high financial leverage may have fewer resources to allocate to sustainable initiatives due to the pressure to repay debt. Meanwhile, greater concentration of decision-making power in a single person may negatively influence the importance placed on ESG practices, as decisions may be guided by personal interests which affect agency cost due to possible private benefit. However, the relationships between Lev and Duality and the ESG variable are not always statistically confirmed by the analysis. Finally, R<sup>2</sup> is consistent with findings in the existing literature (Yang et al., 2023; Peng et al., 2023).

These results validate H1 and H2.

		Dependent Variable			
	ESG				
	(1)	(2)	(3)		
	OLS	RE	FE		
Digital	0.032 <sup>***</sup>	0.019 <sup>**</sup>	$0.018^{*}$		
	(0.007)	(0.008)	(0.009)		
Age	0.061 <sup>***</sup>	$0.087^{***}$	$0.160^{***}$		
	(0.008)	(0.016)	(0.030)		
Size	0.074 <sup>***</sup>	$0.071^{***}$	$0.065^{***}$		
	(0.006)	(0.010)	(0.015)		
Lev	-0.028	-0.085*	-0.090		
	(0.043)	(0.051)	(0.058)		
ROA	0.367***	$0.146^{**}$	0.124*		
	(0.095)	(0.071)	(0.073)		
Indep	0.721 <sup>***</sup>	$0.480^{***}$	$0.424^{***}$		
	(0.070)	(0.066)	(0.070)		
Duality	-0.031**	-0.010	-0.005		
	(0.013)	(0.013)	(0.014)		
Ind	Yes	Yes	Yes		
Year	Yes	Yes	Yes		
Observations	1,778	1,778	1,778		
$\mathbb{R}^2$	0.232	0.097	0.167		

 Table 7: The impact of digital transformation on ESG performance, fourth step.

Notes: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01; standard errors in parentheses.

Source(s): Authors' work

## 4.4 The Impact of Digital Transformation on the Three Dimensions of the ESG Score

An additional analysis was conducted to evaluate the impact of digital transformation on each of the three pillars in the overall ESG score: the environmental (E score), social (S score), and corporate governance dimensions (G score). We follow the same methodology, approaches and test improved for the baseline regression.

Regarding the environmental dimension ("E score"), the results are reported in Table 8. The Digital variable is always positive related to E score although not always statistically significant in all three models. From a theoretical perspective, digital transformation facilitates "green innovation" and enables the development of sustainable products; the adoption of digital technologies allows for the monitoring and optimization of energy consumption, reducing waste; the implementation of digital solutions enhances supply chain management. Digitalization also enables remote work, thereby reducing CO2 emissions associated with daily commuting. All these factors contribute to improving companies' environmental performance. The partially significant results in the analysis might be because digital transformation does not always have a direct and immediate impact on the environmental dimension of ESG. Digitalization is often used by companies to improve efficiency, reduce costs, or innovate processes, but not always with the explicit goal of reducing environmental impact. Moreover, the environmental benefits derived from digitalization may take time (even many years) to materialize, as in the case of adopting green technologies or intelligent systems for resource management and consumption optimization. Furthermore, the positive effects might be counterbalanced by negative impacts and negative externalities (Schoenmaker and Schramade, 2021, 2024) such as increased energy consumption associated with the use of new technologies, which could neutralize the overall result. Furthermore, the rapid adoption of new digital technologies often generates large amounts of electronic waste (e-waste), which can have a negative impact on the environment if not properly managed. The production and distribution of digital devices (servers, computers, etc.) require natural resources and industrial processes that can cause environmental harm, such as the extraction of rare minerals and pollution. All these factors can explain why, in some cases, digital transformation does not automatically strongly translate into an improvement in environmental indicators.

		Dependent Variable			
	<i>E score</i>				
	(1)	(2)	(3)		
	OLS	RE	FE		
Digital	$0.074^{***}$	0.032	0.010		
	(0.021)	(0.026)	(0.030)		
Age	$0.187^{***}$	0.228 <sup>***</sup>	0.532***		
	(0.024)	(0.047)	(0.105)		
Size	0.218 <sup>***</sup>	0.244 <sup>***</sup>	0.316 <sup>***</sup>		
	(0.016)	(0.028)	(0.053)		
Lev	0.227*	0.084	0.101		
	(0.125)	(0.166)	(0.202)		
ROA	0.715 <sup>***</sup>	0.504**	$0.476^{*}$		
	(0.275)	(0.241)	(0.253)		
Indep	0.829***	0.536**	0.443*		
	(0.201)	(0.219)	(0.244)		

 Table 8: Results of the Regression Analysis: Environmental Dimension.

Duality	-0.037 (0.038)	0.058 (0.043)	$0.090^{*}$ (0.048)
Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,778	1,778	1,778
$\mathbb{R}^2$	0.195	0.078	0.153

Notes: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01; standard errors in parentheses.

#### Source(s): Authors' work

Regarding the social dimension ("S" score) reporting in Table 9, as the environmental dimension, we point out a positive and significant impact of digital transformation on companies' social performance for two of the three models improved. From a theoretical perspective, digital transformation should enable improvements in companies' social performance. Digital transformation provides a wide range of communication and interaction channels, helping companies better communicate with various stakeholders, thereby promoting transparency and collaboration; new digital technologies facilitate the monitoring of working conditions and improve workplace safety, fostering respect for workers' rights. Moreover, as mentioned earlier, digitalization supports flexible working arrangements, enabling employees to better manage their time and achieve a better work-life balance, which contributes to their overall well-being. However, as mentioned earlier regarding the environmental dimension, digital transformation is a long and complex process that often does not yield immediate effects but rather takes place over the medium to long term. Its impact on corporate social responsibility may not be immediately and strongly identified. Additionally, large companies often already have well-established corporate social responsibility structures, so digitalization may not lead to radical changes in these areas. While the adoption of new technologies can enhance existing practices, it does not necessarily result in substantial improvements in social performance that could be perceived as significant. If digitalization is not accompanied by a genuine reorganization of social practices, improvements in social performance may remain marginal or merely theoretical, without translating into tangible impacts on the well-being of employees or communities.

	_	Dependent Variable	
		S score	
	(1)	(2)	(3)
	OLS	RE	FE
Digital	0.049***	$0.018^{*}$	0.008
Digitut	(0.009)	(0.010)	(0.011)
100	0.036***	$0.072^{***}$	0.153***
Age	(0.011)	(0.020)	(0.037)
Size	0.075***	0.065***	0.055***
5126	(0.007)	(0.012)	(0.019)
Lev	-0.037	-0.014	0.011
	(0.055)	(0.063)	(0.071)
ROA	$0.490^{***}$	$0.176^{**}$	0.141
КОЛ	(0.120)	(0.087)	(0.089)
Indon	0.692***	$0.488^{***}$	$0.444^{***}$
таер	(0.088)	(0.081)	(0.086)
Duality	0.010	-0.005	-0.006
Dudiliy	(0.017)	(0.016)	(0.017)

**Table 9:** Results of the Regression Analysis: Social Dimension.

Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,778	1,778	1,778
$\mathbb{R}^2$	0.151	0.057	0.140

Notes: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01; standard errors in parentheses.

Source(s): Authors' work

Finally, to evaluate the effect of digital transformation on corporate governance performance (G score) we improved analysis reported in Table 10. The empirical findings show a positive coefficient for the level of companies' digital transformation (0.036), which is statistically significant at the 5% level. It may therefore be stated that investments in digital technologies contribute to improving governance performance. New digital technologies may offer various opportunities in the corporate governance area. Firstly, they can enhance the transparency of business operations and communication between executives, board members, and various stakeholders. Additionally, the use of advanced analytics tools allows companies to make evidence-based decisions and better monitor and manage potential risks in real-time. Of course, for digital transformation to have a real and tangible impact on corporate governance, it must be accompanied by robust governance practices.

In this regard, it is interesting to analyze the coefficients of the variables *Indep* and *Duality*, which reflect the governance characteristics of the companies. As shown in column (3), the coefficient for the variable representing the proportion of independent directors on the board of directors is 0.397, with statistical significance at the 1% level. Therefore, a board composed of a substantial number of independent directors significantly improves companies' governance scores. This result is straightforward to understand, as independent directors ensure greater oversight, transparency, and objectivity and promote the adoption of solid and responsible decisions.

Conversely, the coefficient for the variable related to CEO duality is negative, at -0.058, also with statistical significance at the 1% level. The presence of a single individual holding both the CEO and Board Chair roles has a significant negative effect on corporate governance scores, as this situation reduces transparency, leads to decisions based on personal interests, and hinders debate and diversity of opinions within the board.

These results support H3.

		Dependent Variable	
	G score		
	(1)	(2)	(3)
	OLS	RE	FE
Digital	-0.008	0.023*	$0.036^{**}$
	(0.010)	(0.012)	(0.014)
Age	0.054***	$0.070^{***}$	0.137***
	(0.012)	(0.022)	(0.049)
Size	0.033 <sup>***</sup>	0.032**	0.017
	(0.008)	(0.013)	(0.024)
Lev	-0.090	-0.222***	-0.290***
	(0.060)	(0.078)	(0.093)
ROA	0.104	0.096	0.123
	(0.132)	(0.110)	(0.117)

Table 10: Results of the Regression Analysis: Governance Dimension.

Indep	0.859 <sup>***</sup> (0.096)	0.527 <sup>***</sup> (0.102)	0.397 <sup>***</sup> (0.113)
Duality	-0.111*** (0.018)	-0.071*** (0.020)	-0.058*** (0.022)
Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,778	1,778	1,778
$\mathbb{R}^2$	0.102	0.049	0.134

Notes: \*p<0,1; \*\*p<0,05; \*\*\*p<0,01; standard errors in parentheses.

## Source(s): Authors' work

In the end, the empirical results indicate that the impact of digital transformation on the three dimensions of the ESG score show different impact, sign and statistical significance, with interesting evidence in terms of governance quality.

These results support H2 and H3.

However, from a theoretical perspective, considering the above arguments, the impact of digital transformation can be regarded as positive across all dimensions of the ESG score, including the environmental and social dimensions with partially different empirical finding form studies conducted on Chinese companies (Peng et al. 2023; Yang and Han,2023). These findings must be interpreted considering a variety of factors related to structural, cultural, and regulatory differences between the two markets.

## 4.5 Robustness test and endogeneity concerns

Previous studies have suggested that there may be a reciprocal relationship between enterprise digital transformation and ESG performance, meaning that better ESG performance could encourage companies to undertake proactive digital transformation in search of new opportunities for innovation. To address endogeneity concerns, the study, as mentioned earlier, was implemented using the variable related to the level of digital transformation in companies and other control variables lagged by one period. Indeed, considering the overall impact of digital transformation on ESG performance, when companies formulate their digital transformation strategies, the driving effect takes time to materialize. To ensure greater robustness of the model and further mitigate endogeneity interference, a two-period lag was applied to the variable related to the level of digital transformation in companies and the other control variables. The test results in table 11 show that the sign of the regression results is unchanged, proving that the baseline regression results of this paper are robust.

	Dependent Variable			
		ESG		
	(1) OL S	(2) DE	(3) EE	
	0L5		FE	
Digital	0.023 (0.008)	0.018 (0.008)	(0.016)	
Age	$0.051^{***}$ (0.009)	$0.076^{***}$ (0.016)	0.157 <sup>***</sup> (0.032)	

Table 11: Robustness tests with a two-stage lag

Size	0.069 <sup>***</sup>	$0.063^{***}$	$0.052^{***}$
	(0.006)	(0.010)	(0.016)
Lev	0.005	0.035	0.060
	(0.045)	(0.052)	(0.061)
ROA	0.384 <sup>***</sup>	0.128 <sup>*</sup>	0.106
	(0.105)	(0.076)	(0.079)
Indep	0.592***	0.244 <sup>***</sup>	0.152**
	(0.071)	(0.066)	(0.071)
Duality	-0.038***	-0.021	-0.015
	(0.014)	(0.014)	(0.015)
Ind	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	1,524	1,524	1,524
$\mathbb{R}^2$	0.207	0.071	0.139

Notes: \*p<0,1; \*\*p<0,05; \*\*\*p<0,01; standard errors in parentheses

Source(s): Authors' work

### 5. Conclusions

In the context of the rapid development of the global digital economy, digital transformation has become a mandatory strategic choice for companies, as it enables them to adapt to an increasingly evolving and dynamic economic environment. Companies must embark on the digital transformation journey to innovate their business models, optimize production processes, and improve operational efficiency to create long-term value. In an increasingly competitive market, the adoption of digital solutions allows companies to make more informed decisions, develop new products, and respond quickly to customers' increasingly complex and sophisticated needs. Research in existing literature has mainly focused on the economic value creation effects of digital transformation. Few studies have investigated the influence of digital transformation on companies' non-financial performance. The objective of this research was to expand the knowledge in this still under-explored area of study as a crucial topic in the recent global economic context.

Specifically, using data from a sample of 254 publicly listed companies belonging to S&P 500, from 2015 to 2022, a study was conducted to assess the impact of digital transformation on companies' ESG performance. The results showed that the degree of digital transformation has a significant and positive influence on ESG performance. In particular, the positive effect of digital transformation was observed with different size and statistical significance among the three different pillars of E, S and G score. The study highlights interesting evidence for E and S but moreover to whom it concerns governance issues corporate governance quality. According to these findings we may place this study in the field of research founding "empowerment" effect.

This study offers several noteworthy implications from both theoretical and practical perspectives. From a theoretical perspective, the study contributes to deepening research on digital transformation, emphasizing that it is not just an internal matter for companies, but has significant repercussions on the social context in which companies operate. Companies can no longer view digital technologies as merely tools to improve business operations; rather, digital transformation should be seen as a catalyst for change that can have positive effects on corporate sustainability. In this regard, the study also contributes to expanding the debate on the various factors influencing companies' ESG performance. From a practical perspective, this study aims to provide valuable insights for both policymakers and business leaders. For policymakers, it is crucial to accelerate the creation of digital infrastructures and expand the availability of internet networks and broadband connections, ensuring wider dissemination of new technologies. To support companies' digital transformation and, consequently, their sustainability, governments should create a favorable institutional environment through policies that promote innovation and provide effective incentives, with particular attention to non-tech companies and small and medium-sized enterprises (SMEs). Preferential policies, subsidies, and tax incentives could help reduce the costs associated with the digital transformation process and increase companies' motivation to embark on this journey. In terms of implications at the corporate level, companies should make the most of the opportunities offered by digital transformation to pursue highquality development. Of course, extreme approaches that do not respect the company's capacities and limitations should be avoided, as this could prove counterproductive. In this context, a key aspect is the expansion of managerial competencies: companies should enhance their managerial backgrounds by investing in training their managers to strengthen their knowledge and practical skills. Only by following this approach will companies be able to integrate new digital technologies into business processes more effectively and efficiently, maintaining and improving their competitiveness in an ever-evolving context like the current one. In conclusion, this study broadens the theoretical horizon regarding the effects of digital transformation at the corporate level, while providing practical recommendations for companies dealing with the challenges and opportunities of digital transformation, as well as for governments, to create a conducive environment for executing this process.

We are aware that this study has limitations. First, to gain more robustness of empirical results it would be interesting to consider other different approaches: one idea may consider a new proxy variable to replace the explanatory variables to examine the impact of digital transformation on corporate ESG performance. Further approaches to analyze the robustness of empirical results could consider dividing into two sub-groups based on the different industry orientation (production or consumer) or replace ESG data using scoring from other data provider. Finally, we need to better address potential endogeneity issues in the model constructing instrumental variables for digital transformation. We are working on these improvements. Furthermore, due to data availability, the specific mechanisms through which digital transformation affect ESG performance were not investigated. Future research could analyze the potential mechanisms through which digital transformation influences ESG performance. Lastly, as observed in this study and by literature, Digital transformation may affect governance issues, improving quality of governance. Advanced data analysis techniques, predictive analytics tools and digital transformation may reduce informational asymmetries, improving transparency and ensuring more effective internal and external oversight of business operations. These factors enhance corporate governance, with possible benefits in reducing corruption at firm level but not only. (Hacioglu and Aksoy, 2021 among the others). The recent literature on these topics is flourishing and full of interesting approaches, nevertheless the results are not always robust and consistent (Malik and Froese, 2022; Merhi, 2022; Bajestani et. al, 2024). This is an interesting channel to reduce corruption and represent a potential way to create sustainable long-term value, with a greater impact at company level. According to what we mentioned, this relationship represents an interesting topic to analyze for future research agenda.

## REFERENCES

BAJESTANI M.F., GHARAGOZLOO M.M.M, LI S. Digital Technologies: Anti or Pro Corruption? Journal of Global Information Technology Management, vol 27, Issue 3 pp. 182-199, 2024.

BELLAVITE PELLEGRINI C., PELLEGRINI L., CATIZONE M, Climate Change Adaptation, Governance and New Issues of Value: Measuring the Impact of ESG Scores on CoE and Firm Performance, Palgrave MacMillan, London, 2022.

CAI C., TU Y., LI Z., Enterprise digital transformation and ESG performance, Elsevier, 2023.

CRUPI A., MAROZZO V., Trasformazione digitale e open innovation. La prospettiva delle piccole e medie imprese, tab edizioni, Roma, 2023.

FANG M., NIE H., SHEN X., Can enterprise digitization improve ESG performance? Elsevier, 2023.

FREEMAN R.E., Strategic management: A stakeholder approach. Boston, Pitman, Boston, 1984.

GAGLIO C., KRAEMER-MBULA E., LORENZ E., *The effects of digital transformation on innovation and productivity: firm-level evidence of South African manufacturing micro and small enterprises*, Technological Forecasting and Social Change, 2022.

GUO L., XU L., *The effects of digital transformation on firm performance: Evidence from China's manufacturing sector*, MDPI, 2021.

HACIOGLU U., AKSOY T., Financial Ecosystem and Strategy in the Digital Era, Springer, 2021.

JARDAK M. K., SALAH B. H., *The effect of digital transformation on firm performance: Evidence from Swedish listed companies*. Journal of Risk Finance, 2022.

JIANG K., DU X., CHEN Z., *Firms' digitalisation and stock price crash risk*, International Review of Financial Analysis, 2022.

LI H., WU Y., CAO D., WANG Y., Organisational mindfulness towards digital transformation as a prerequisite of information processing capability to achieve market agility, Journal of Business Research, 2021.

LSEG DATA & ANALYTICS, *Environmental, social and governance scores from LSEG*, 2023. Available at: <u>https://www.lseg.com</u>

LUO Y., TIAN N., WANG D., HAN W., Does Digital Transformation Enhance Firm's ESG Performance? Evidence from an Emerging Market, Taylor & Francis Group, 2023.

MALIK A., FROESE F. J., Corruption as a perverse Innovation: The dark side of digitalization and corruption in international business, Journal of Business Research, 2022.

MERHI, M. The Effect of Digital Transformation on Corruption: A Global Analysis. Pacific Asia Journal of the Association for Information Systems, Vol 14. Issue (2) 2022.

PENG Y., CHEN H., LI T., The Impact of Digital Transformation on ESG: A Case Study of Chinese-Listed Companies, MDPI, 2023.

REN X., ZENG G., ZHAO Y., Digital Finance and Corporate ESG performance: empirical evidence from Listed Company in China. Pac. Basin Finance J. 79, 102019.

RUSH, M., SCHOGGL, J.P. AND BAUMGARTNER, R.J. "Application of Digital Technology for Sustainable product management in a circular economy: a review" Business Strategy and Environment, vol. 32. N. 3, pp 115-1174., 2023.

SCHOENMAKER D., SCHRAMADE W., *Which discount rate for sustainability?*, Journal of Sustainable Finance and Accounting, 2024.

SCHOENMAKER D., SCHRAMADE W. "Corporate Finance for Long Term Value" Springer, 2024.

SCHOENMAKER D., SCHRAMADE W. Principle of Sustainable Finance" DOxford University Press, 2021.

SU X., WANG S., LI F., The Impact of Digital Transformation on ESG Performance Based on the Mediating Effect of Dynamic Capabilities, MDPI, 2023.

WANG H., JIAO S., BU K., WANG Y., WANG Y., Digital transformation and manufacturing companies' ESG responsibility performance, Finance Research Letters, 2023.

WANG L., HOU S., The impact of digital transformation and earnings management on ESG performance: evidence from Chinese listed enterprises, Scientific Reports, 2024.

WANG Y., GUO Y., Firm Digital Transformation and ESG Performance: Evidence from China's A-share Listed Firms, Journal of Finance and Economics, 2023.

WANG J., WANG W., WU H., LIU Y., *Exploring the effects of manufacturing servitization on enterprise energy conservation and emissions reduction moderated by digital transformation*, Energy Economics, 2023.

WEN H., ZHONG Q., LEE C.C., *Digitalization, competition strategy and corporate innovation: evidence from Chinese manufacturing listed companies*, International Review of Financial Analysis, 2022.

WU S., LI Y., A Study on the Impact of Digital Transformation on Corporate ESG Performance: The Mediating Role of Green Innovation, MDPI, 2023.

WU X., LI L., LIU D., LI Q., Technology empowerment: Digital transformation and enterprise ESG performance-Evidence from China's manufacturing sector, PLOS ONE, 2024.

YANG P., HAO X., WANG L., ZHANG S., YANG L., *Moving toward sustainable development: the influence of digital transformation on corporate ESG performance*, Emerald Publishing Limited, 2023.

YANG X., HAN Q., Nonlinear effects of enterprise digital transformation on environmental, social and governance (ESG) performance: evidence from China, Emerald Publishing Limited, 2024.

ZENG H., HANGXIN R., QIONG Z., YOULIANG J., XU C., *The financial effect of firm digitalization: Evidence from China*. Technological Forecasting and Social Change, 2022.

ZHANG L., YE Y., MENG Z., MA N., WU C. H., *Enterprise Digital Transformation, Dynamic Capabilities, and ESG Performance: Based on Data From Listed Chinese Companies,* Journal of Global Information Management, 2024.

ZHAO X., CAI L., Digital transformation and corporate ESG: Evidence from China, Elsevier, 2023.

ZHONG Y., ZHAO H., YIN T., Resource Bundling: How Does Enterprise Digital Transformation Affect Enterprise ESG Development?, MDPI, 2023.

## APPENDIX

Category	Keywords
Artificial Intelligence Technology	Artificial intelligence, Business intelligence, Deep analysis, Deep learning, Machine learning, Natural language processing, Intelligent data analysis,
	Semantic search, Image understanding, Face recognition, Voice recognition,
	Identity verification, Biometrics, Intelligent robotics, Autonomous driving,
	Semantic search, Investment decision support systems
Big Data Technology	Big data, Data acquisition, Data mining, Text mining, Data visualization,
	Heterogeneous data, Data-driven, Extended reality, Augmented reality, Mixed
	Charl El Stration Stration Stration
Cloud Computing Technology	Memory computing, multi-party secure computing, Brain-like computing,
	Green computing, Cognitive computing, Fusion architecture, Converged
	architecture, Digital twin, Billion-level Concurrency, EB-level storage, Internet
	of Things, Cyber-Physical Systems
Blockchain Technology	Blockchain, Distributed ledger, Digital currency, Distributed computing,
	Decentralized computing, Differential privacy technology, Smart contracts;
Digital Technology applications	Digitization, Digitalization, Digital transformation, Mobile internet, Social
	media, Quantum computing, Industrial internet, Industrial analytics,
	Information technology, Mobile interconnection, Internet healthcare, Internet
	medicine, E-commerce, Mobile payment, Third-party payment, NFC payment,
	Smart energy, B2B, B2C, C2B, C2C, O2O, Networked, Smart systems, Smart
	production, Smart factory, industry 4.0, industrial robots, Advanced
	automation, Additive manufacturing, Cloud manufacturing, Advanced Human-
	Machine Interface, Smart wearables, Smart agriculture, Smart transportation,
	Smart medical, Smart customer service, Smart home, Robo-advisors, Smart
	tourism, Smart environmental protection, Smart grid, Smart marketing, Digital
	marketing, Unmanned retail, Internet finance, Digital finance, Fintech,
	Financial technology, Quantitative finance, Open banking

## Table A.1: Summary of Digital Transformation Keywords

**Source(s):** Authors' work

	ESG	Digital	Age	Size	Lev	ROA	Indep	Duality
ESG	1							
Digital	0,139***	1						
Age	0,278***	-0,043	1					
Size	0,407***	0,063**	0,284***	1				
Lev	0,035	-0,140***	0,015	0,181***	1			
ROA	-0,011	0,162***	-0,046*	-0,272***	-0,208***	1		
Indep	0,320***	-0,030	0,146***	0,177***	0,112***	-0,070**	1	
Duality	-0,023	-0,040	0,208***	0,041	-0,011	-0,006	-0,100***	1

# Table A.2: Correlation analysisPearson correlation coefficient

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Source(s): Authors' work

# Table A.3: Collinearity diagnosticsVariance Inflation Factor measure (VIF).

Variable	(1)	(2)
	VIF	1/VIF
Digital	1,065315	0,9386892
Age	1,162354	0,8603233
Size	1,238857	0,8071958
Lev	1,090311	0,9171699
ROA	1,144032	0,8741015
Indep	1,070714	0,9339563
Duality	1,066012	0,9380758

Source(s): Authors' work