DIGITAL TRANSFORMATION AND CORPORATE ESG PERFORMANCE: THE ROLE OF BOARD GENDER DIVERSITY

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Abstract

This study empirically examines the impact of digital transformation (DT) on firm environmental, social, and governance (ESG) performance using data from Italian listed companies for the year 2023. It also investigates whether board gender diversity has a moderating role in this association. To date, only a handful of empirical studies have examined the moderating role of board gender diversity between DT and corporate ESG performance, and their findings are mixed. This paper is an attempt to bridge this gap. The empirical findings indicate that: 1) DT has a significant positive impact on corporate ESG performance, and 2) board gender diversity strengthens the positive impact of DT on ESG performance. This result diverges from previous research, which suggests that board gender diversity has a negative moderating effect between DT and ESG performance. This study challenges these previous findings and suggests instead that board gender diversity may enhance a firm's ability to reap ESG benefits from DT.

Keywords: Digital Transformation, Board Diversity, ESG Performance

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1. INTRODUCTION

With the exponential spread of digital technologies (e.g., artificial intelligence, Internet of Things (IoT), big data), digital transformation (DT) has become a pervasive trend globally and a viable strategic option for firms to pursue sustainable development (Yang & Han, 2023; Su & Wu, 2024). DT is defined as the process of using digital technologies to enable major business improvements such as enhancing customer experience, streamlining operations, or creating new business models (Fitzgerald et al., 2013).

In response to the ubiquitous trend of DT, the scientific community is increasingly interested in the impact of DT on firm performance. The existing research suggests that DT can not only enhance the economic performance of firms such as profitability (Zhai et al., 2022), investment efficiency (Yu & Shao, 2024), innovation performance (Li & Zhu, 2025) and capital market performance (Elafify & Wang, 2024), but can also enhance their environmental, social and governance (ESG) performance (Chen & Hao, 2022; Fang et al., 2023; Song et al., 2025).

DT is believed to promote the fulfilment of ESG responsibilities in several ways, e.g., by improving resource allocation efficiency (de Sousa Jabbour et al., 2018), increasing the transparency of corporate information (Chen & Hao, 2022), enhancing firm internal controls (Lu et al., 2024) and boosting green innovation capabilities of firms (Wang et al., 2023). However, researchers have just begun to explore the mechanisms underlying the association between DT and ESG performance and the firm contingency factors that moderate this association (Chen &

Ren, 2025). Interestingly, recent research suggests that the composition of corporate boards and the degree of board diversity in particular can affect the association between DT and ESG performance (Chen & Hao, 2022; Lu et al., 2024). While research abounds on the link between board diversity and ESG performance (Beji et al., 2021; Naciti, 2019; Nadeem et al., 2017; Orazalin & Baydauletov, 2020; Glass et al., 2016; Galbreath, 2011), to our knowledge, only a handful of studies (Chen & Hao, 2022; Zhang et al., 2024; You & Luo, 2024) have explored whether board diversity moderates the impact of DT on ESG performance, and their findings are inconclusive. This paper is an attempt to fill this gap. Therefore, the central research question underlying this study is:

RQ: Does board gender diversity moderate the impact of digital transformation on firms' environmental, social, and governance performance?

In order to address this research question, we first quantify the level of DT in a sample of Italian listed firms. Specifically, leveraging the recent advances in textual analysis and a manual reading of annual reports, we quantify whether a firm has DT and the extent of its DT. We then performed a multiple regression (ordinary least squares [OLS]) analysis to empirically assess its impact on ESG performance and the moderating effect of board gender diversity.

The empirical findings suggest that DT has a positive impact on corporate ESG performance and that firms with a higher representation of women on their boards of directors appear more inclined to adopt DT initiatives that enhance their commitment to ESG. These results contribute to the emerging research on DT and ESG performance in at least two respects.

First, this study provides further empirical evidence that DT improves corporate ESG performance, thus corroborating previous research findings (Zhang et al., 2024; Lu et al., 2024; Song et al., 2025). Second, and more importantly, this study enriches the scant research literature that has explored the interplay between DT, board diversity, and ESG performance by providing evidence that board gender diversity can enhance the positive impact of DT on ESG performance. This result diverges from previous research, such as Zhang et al. (2024) and You and Luo (2024), which find a negative moderating effect of board gender diversity. These previous researchers argue that the cautious attitude and risk preference exhibited by female directors may cause firms to miss out on the opportunities of DT, thus impeding its promoting effect on corporate ESG performance. Our finding challenges this view and suggest instead that the advantages of board gender diversity may outweigh its potential drawbacks in promoting DT initiatives that improve ESG performance.

The remainder of this paper is structured as follows. Section 2 reviews the existing literature on DT and ESG performance, as well as the literature that supports the potential moderating role of board gender diversity, and poses the research hypotheses accordingly. Section 3 provides the variable description and outlines the methodology, the data collection procedure, and the empirical strategy. Section 4 presents the empirical findings and their interpretation. Section 5 summarizes the study, discusses practical implications and the study's limitations, while also outlining future research directions.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Digital transformation and environmental, social, and governance performance

Increasingly, scholars argue that DT can lead to improving the ESG performance of firms. Several reasons have been proposed for why DT should promote firm engagement with ESG issues. First, it is argued that DT, by increasing resource allocation efficiency, helps firms achieve a sustainable production model (Chen & Hao, 2022). For instance, de Sousa Jabbour et al. (2018) contend that, by leveraging digital technologies to gain real time data from production systems and supply chain partners, firms can optimize the allocation of resources such as materials, energy, water and products, and this promotes environmentally-sustainable growth by enabling the development of green products, green manufacturing processes and green supply chain management. In a similar vein, Wang et al. (2023) argue that DT promotes the structural optimization of production and operation activities from the manufacturing stage to supply and marketing, helping firms to advance productivity, reduce pollution emissions and even more fundamentally by boosting their green technology innovation capabilities.

Second, it is argued that DT boosts ESG performance through enhancing the information processing ability and the responsiveness of firms to stakeholder demands (Chen & Hao, 2022). According to Song et al. (2025), DT by enabling firms to handle large amounts of data can help them to quickly identify and respond to the diverse value demands of stakeholders as well as rapidly capture social pain points and public environmental issues matching them with firm resource and capabilities, which ultimately promotes and improves the quality of their ESG engagement. Furthermore, DT enables more extensive and rapid communication with other economic entities (Broccardo et al., 2023) and thus provides the management of firms with a stronger external perception, reducing irrational and inefficient decision-making behaviours. Song et al. (2025) provide evidence that DT enhances the ability of management to obtain information and the efficiency of managerial decision-making, and this mechanism promotes ESG engagement.

Third, research suggests that DT can improve corporate ESG performance by enhancing corporate internal controls and reducing the agency costs between the firm and its stakeholders. For instance, Zhang et al. (2025) suggest that DT promotes ESG performance by optimizing internal controls and improving the information disclosure quality. On the one hand, they argue, DT improves the efficiency of information sharing and communication within the firm, breaking down the "departmental walls" and enabling rapid resource mobilization to optimize internal control; on the other hand, DT improves the quality of external information disclosure, which, in turn, reduces the level of information asymmetry between managers and firm stakeholders, creating a conducive environment for the proactive fulfilment of ESG responsibilities. In the same vein, Fang et al. (2023) provide evidence that DT can enable firms to reduce information asymmetries and agency costs between stakeholders and improve stakeholder goodwill through enhanced engagement and corporate information disclosure, thus improving

their governance and social performance. Lu et al. (2024) also find that DT promotes ESG engagement by enhancing the quality of corporate internal controls, which has been linked to improved ESG ratings (Boulhaga et al., 2023) in turn.

Fourth, as recent research suggests (Chen et al., 2022), DT enriches capital market information resources and reduces analysts' costs to obtain information, including ESG-related information. These researchers find that analyst following significantly increases, and the accuracy of analysts' public information significantly improves after these firms undergo DT. This suggests that DT can promote the transparency of information in the capital market. Thus, arguably, DT will drive firms to enhance their ESG efforts as a means to attract investors who place growing importance on ESG compliance (Liu & Jung, 2021; Lu et al., 2024). This notion has been supported recently by Song et al. (2025), who find that firms that undergo DT are more likely to face external pressures from media and analysts to fulfil their ESG responsibilities and that investors place value on DT initiatives that increase their ESG engagement.

In conclusion, research has provided convincing arguments and consistent evidence to suggest that DT has a positive impact on ESG performance (Chen & Hao, 2022; Fang et al., 2023; Wang & Guo, 2023; Zhang et al., 2022; Lu et al., 2024; Song et al., 2025) although this impact may be not necessarily linear (Yang & Han, 2024). Given the above arguments and empirical evidence, we propose the following hypothesis:

H1: Digital transformation can improve corporate environmental, social, and governance performance.

2.2. The moderating effect of board gender diversity

Board composition and, in particular, board gender diversity have gained increasing attention as an important determinant of firm ESG performance (Cambrea et al., 2023). Scholars have leveraged several theories to support this connection, including the agency theory, the resource dependency theory, and the group diversity theory, among others.

From an agency theory perspective, it is argued that diversity increases board independence from management because people with different genders, ethnicity, or cultural backgrounds might ask questions that would not come from directors with more traditional backgrounds (Carter et al., 2003). In this regard, Nielsen and Huse (2010) maintain that female directors may substantially contribute to monitoring managerial decisions regarding corporate social responsibility and environmental politics, due to their participative management style, their greater attention to the needs of others, and a higher sensitivity compared to their male colleagues. From this perspective, thus, gender diverse boards may promote ESG performance through a more effective monitoring of managerial decisions that concern ESG-related issues.

From a resource dependence theory (RDT) perspective (Pfeffer & Salancik, 1978), gender diversity is argued to enrich the stock of board resources and capabilities, providing different competencies, information, and attitudes that can stimulate environment-friendly and socially responsible decision-making in the boardroom. For instance, Hillman et al. (2002) suggest that female directors may bring different competencies and stakeholder-oriented value to corporate boards, because they are more likely to be business support specialists or community influential rather than business experts or insiders, often due to their non-conventional career paths. Singh et al. (2006) also find that women are more likely to possess community-related expertise, while Kramer et al. (2006) document that female board representation enriches the boardroom discussion by incorporating the viewpoints of diverse stakeholders. Due to their stakeholder orientation and different backgrounds, female directors may, more frequently than males, contribute to fostering firm engagement with ESG issues.

Similarly, according to the group diversity theory, board gender diversity may carry informational diversity (i.e., access to different knowledge bases or networks), social category diversity (i.e., salient and symbolically meaningful differences in social group membership), value diversity (e.g., differences in beliefs about corporate social responsibility), or combinations thereof (Jehn et al., 1999). Drawing upon the group diversity theory, Post et al. (2011) contend that female directors tend to hold more information and more favourable attitudes toward environmental issues than their male counterparts. Braun (2010) documents that female directors are more engaged in environmental issues, and this may enhance board efficiency concerning the environmental policy of firms.

Female board representation on boards may have social impacts as well. Previous research found that women think more favourable of ethical matters than men (Luthar et al., 1997) and tend to be more sensitive to corporate social performance, including philanthropic commitment.

To date, a good deal of research has provided evidence that board gender diversity promotes ESG performance (Cambrea et al., 2023; Romano et al., 2020), although a few studies have reported conflicting results. However, thus far, research has largely neglected the potential moderating role of board gender diversity in the relation between DT and ESG performance. To the best of our knowledge, only three studies have explicitly investigated this potential moderation effect, with mixed results. Chen and Hao (2022) find that female board representation enhances the positive effect of DT on corporate environmental performance. In contrast, Zhang et al. (2024) and You and Luo (2024) find that board gender diversity weakens the positive impact of DT on ESG performance. They argue that board gender diversity, due to the cautious attitude and risk aversion of female directors, can lead to slower decision-making or resistance to change, particularly in the context of DT that requires substantial investment and carries inherent risk. Given these conflicting findings and arguments, we pose the related hypothesis in the null form:

H2: Female board representation moderates the positive impact of digital transformation on corporate environmental, social, and governance performance.

3. RESEARCH METHODOLOGY

3.1. Sample

Our initial sample comprised all firms listed on the Italian Stock Exchange in the year 2023. Data

were collected from multiple sources. The ESG scores were collected from the Refinitiv Eikon database, now LSEG Data & Analytics. Financial and accounting data were sourced from the Computerized Analysis of Italian Companies (*Analisi Informatizzata delle Aziende Italiane* — AIDA). Corporate governance data, such as the number of female and independent directors and board size, were hand-collected from the corporate governance reports.

After removing firms with missing data and financial firms, we were left with a final sample of 88 firms. This is mainly due to the limited number of ESG scores available on Refinitiv Eikon for Italian-listed firms. Table 1 presents the distribution of the sample by the Global Industry Classification Standard (GICS). The industries with the largest representation include: industrials (34%), consumer discretionary (29%), and technology (9%).

Table 1. Sample composition by industry

Industry	*Frequency*	*Percentage*
Industrials	30	34%
Consumer staple	5	6%
Consumer discretionary	26	29%
Telecommunications	5	6%
Energy	3	3%
Health	3	3%
Chemicals	2	2%
Technology	8	9%
Total	88	100%

3.2. Variable measurement

The ESG is measured using the composite ESG score provided from the Refinitiv Eikon database. This score measures firms' ESG performance based on public information data, taking into account comparability, data availability, and industry relevance, ranging from a minimum of 0 to a maximum of 100.

The independent variables of interest in this study are digital transformation (*DT*) and board gender diversity (*BGD*) as measured by the percentage of female directors on the board.

In order to measure *DT*, this study builds upon previous empirical work, which established and validated a digitalization dictionary that identifies the words that a qualified public (made up of professors, PhD students, graduate and undergraduate students) associates with firms' digitalization efforts (Hossnofsky & Junge, 2019). This study summarizes and organizes keywords related to *DT* and uses NVivo software to match text content in companies' annual reports to determine the number of words related to *DT*, wherein more times words related to *DT* appear in an annual report, wherein the higher the degree of *DT* is for that enterprise. To reduce statistical errors, we excluded judgmental words, such as none, not, and no, before and after the word field. Thus, we came up for each firm with the total number of *DT*-related words, as a measure of the degree of firm digitalization.

As additional control variables at the firm level, we include *Firm size*, *Firm age*, the debt-to-equity ratio (*Leverage*), and the return-on-assets (*ROA*) ratio. The control for *Firm size* is particularly important because ESG scores can be subject to *Firm size* bias (Drempetic et al., 2020) as bigger firms may use economies of scale to enhance ESG performance. We use the natural logarithm of total assets as a proxy for *Firm size*. The debt-to-equity ratio is used as a proxy for firm *Leverage* to control for the impact of financial risk on firm ESG performance (Simnett et al., 2009). As more profitable firms are more likely to have better ESG performance, we also control for firm profitability using the *ROA* ratio (Liang & Renneboog, 2017). Finally, we measure *Firm age* as the number of years since a firm's incorporation. Industry effects are also accounted for.

Table 2. Variable definition and measurement

Variable	*Description*	*Source*
ESG	Corporate ESG score	Refinitiv Eikon
DT	Number of digitalization-related words	Company annual report
BGD	Percentage of female directors on the board	Corporate governance report
Firm age	Number of years from a firm's establishment	AIDA database
Firm size	Log-transformed of total assets	AIDA database
ROA	The percentage of return on assets	AIDA database
Leverage	Total debt/equity	AIDA database

4. RESEARCH RESULTS

In order to test our hypotheses, we estimate the following model by using an OLS regression, where the variable *DT*, the percentage of women on the board (*BGD*), and their interaction term (*DT* * *BGD*) are the main variables of interest:

$$ESG = \beta_0 + \beta_1 DT + \beta_2 DT * BGD\beta_3 + \beta_4 Firm\ size + \beta_5 Leverage + \beta_6 Firm\ size + Industry + \varepsilon \quad (1)$$

Table 3 presents the descriptive statistics and pairwise correlations between the variables. The average value of the *ESG* performance is 54.48 with a standard deviation of 17.02 (minimum and maximum values 33.45 and 88.49, respectively), which indicates a large variation in this performance measure. The boards of Italian listed firms are composed, on average, of 39% female directors. The results of the correlation analysis show that both the *DT* variable and the percentage of female directors (*BGD*) have a positive and significant correlation with the *ESG* score, providing some initial support to our research hypotheses. Also, *BGD* has a positive correlation with *DT*, indicating that firms with higher female board representation engage in *DT* to a greater extent. Furthermore, as the variance inflation factors (VIF) values are well below the warning value of 10 (Myers, 1990), we can conclude there are no significant multicollinearity issues in our regression.

Table 3. Means, standard deviations, VIF, and pairwise correlations

Variable	*Mean*	*SD*	*VIF*	*ESG*	*DT*	*BGD (%)*	*Firm size*	*Leverage*	*Firm age*	*ROA (%)*
ESG	54.48	17.02		1.00						
DT	2.31	1.45	1.88	0.28**	1.00					
BGD (%)	38.51	12.22	2.87	0.48***	0.09	1.00				
Firm size	20.91	2.09	1.77	0.46***	0.26*	0.24*	1.00			
Leverage	0.56	3.25	1.52	0.12	-0.00	0.14	0.13	1.00		
Firm age	3.91	0.63	2.24	0.18	-0.19	-0.02	0.24*	0.12	1.00	
ROA (%)	2.25	7.84	1.64	0.238*	-0.01	-0.11	-0.15	0.10	0.07	1.00

*Note: ***, **, * indicate significance at 0.1%, 1% and 5%, respectively.*

Table 4. Multiple regression analysis with main and interaction effects

Variable	*ESG performance*	
	Model 1	*Model 2*
DT	3.66** (1.30)	1.94* (0.98)
BGD		0.38* (0.19)
*DT * BGD*		0.18** (0.06)
Firm age	2.40 (3.03)	2.97 (2.77)
Leverage	0.20 (0.54)	0.11 (0.48)
Firm size	2.15* (0.88)	1.45 (0.81)
ROA	0.38 (0.23)	0.31 (0.21)
Industry dummies	Yes	Yes
Constant	-5.62 (19.56)	-9.35 (18.84)
N	88	88
R^2	0.35	0.49

*Note: ***, **, * indicate significance at 0.1%, 1% and 5%, respectively. Standard errors in parentheses.*

Table 4 presents the estimation results of our econometric model with and without the interaction effect of *BGD* and *DT*. Our hypothesis *H1* predicts that *DT* can improve corporate *ESG* performance. As column (1) shows, the regression coefficient on the *DT* variable is positive and statistically significant ($\beta = 3.66$, $p < 0.01$). This would suggest that *DT* improves the *ESG* performance of Italian listed firms. *H1* is thus supported. This result is consistent with previous findings by Cambrea et al. (2023) and Romano et al. (2020), who also covered Italian listed firms.

Column (2) shows the estimation results, including the interaction variable between *DT* and *BGD*. Our hypothesis *H2* predicts that the proportion of female directors positively moderates the association between *DT* and *ESG* performance. The positive coefficient on the interaction term *DT * BGD* ($\beta = 0.18$, $p < 0.01$) lends support to this hypothesis as well. It implies that *BGD* reinforces the positive impact of digitalization on *ESG*. This finding is consistent with Chen and Hao (2022), who also find that firms with greater female board representation reap more *ESG* benefits from *DT*. Regarding the control variables, we find statistical significance only for *Firm size*, suggesting that large firms are more likely to engage in *ESG* activities.

5. CONCLUSION

This paper was motivated by the lack of empirical studies that examine the interplay between DT, board composition, and ESG performance. To the best of our knowledge, there are only three empirical studies that investigate how DT influences ESG performance through the lens of board diversity. This research is an attempt to fill this gap. Specifically, we investigated the potential moderating effect of board gender diversity on the relation between DT and corporate ESG performance, using data from Italian publicly listed companies relating to the year 2023.

Our empirical findings reveal that 1) DT significantly enhances ESG performance, and 2) board gender diversity positively moderates this relationship. This suggests that firms with a higher proportion of female directors are better positioned to improve their ESG performance by undergoing DT. This finding is consistent with an agency theory view that female directors may substantially contribute to monitoring managerial decisions regarding ESG-related issues, thus promoting DT on the path to sustainable development. However, recent research on Italian listed companies finds that female board members are better able to improve ESG if they hold advisory rather than monitoring roles (Cambrea et al., 2023). Thus, arguably, our finding that greater female representation enhances the positive effect of DT on ESG could be better explained from a resource dependency (or group diversity) perspective, which suggests that female directors, due to their diverse background and stakeholder-oriented attitudes, lean more toward ESG issues and therefore they champion DT initiatives that improve corporate ESG performance.

These findings contribute to the existing research, providing further empirical support for the positive impact of DT on firm ESG performance. In addition, they shed light on the potential moderating role of board composition, enriching the scant research literature that has covered the interplay between DT, board diversity, and ESG performance. In doing so, we contribute on the one hand to the emerging DT literature that has recently begun to explore the firm contingency factors that moderate the relation between DT and corporate ESG performance. On the other hand, this study also contributes to the accumulating body of corporate governance research that in the last few decades has been devoted to assessing the non-economic impacts of board diversity. Our findings also provide practical implications for businesses and policymakers.

For businesses, our findings emphasize the importance of fostering gender diversity in the boardroom, suggesting that a more gender-diverse board may enhance a firm's ability to reap ESG benefits from DT. Consistent with us, recent research suggests that the impact of DT on ESG performance may be different under different board compositions and that a greater female board representation may help reduce the environmental risks associated with DT, for instance (Chen & Hao, 2022). Second, and relatedly, businesses should recognize the importance of raising digital competencies in the boardroom. A recent study by Assonime (the Italian association of Italian joint stock companies) in collaboration with Borsa Italiana (the Italian Stock Exchange) and Alkemy finds that 42% of Italian listed firms have no director with digital competencies on the board.

Regarding policy implications, policymakers should offer targeted subsidies to encourage investments in advanced digital technologies. For instance, according to the latest digital decade report (European Commission [EU], 2024), the Italian government should take specific measures targeted at the adoption of artificial intelligence and big data analytics by Italian businesses, which lags behind the European average. Second, policymakers should focus on the conditions that hamper the twinning of DT and sustainable development specific to their national context.

This study presents some limitations that provide an avenue for further research. First, it uses textual analysis to evaluate DT, which may not fully capture the nuances among the DT strategies of firms. It should also be considered that firms may engage in narrative disclosures that may not reflect their actual digitalization efforts. Second, this study examines the moderating role of board gender diversity but neglects other potentially influential dimensions of board diversity, such as directors' professional backgrounds, cultural diversity, and nationalities. Third, our investigation is limited to listed firms since the information about their DT and ESG is publicly available. Future research may well benefit from comparing the effect of DT between listed and non-listed firms. This is because non-listed firms may incur relatively weaker oversight and monitoring from the government, media, and other stakeholders.

Future research could address these limitations, possibly by employing longitudinal data rather than single time points, and carrying out a cross-country analysis that allows for more generalizable findings.

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