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Does corporate digital transformation restrain ESG decoupling? Evidence from China

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This paper empirically examines the efficacy of corporate digital transformation on a firm's environmental, social, and governance (ESG) decoupling. Adopting the text analysis method and using a sample of Chinese A-share listed firms from 2010 to 2019, this paper finds that digital transformation can significantly alleviate ESG decoupling, and this relationship persists after robustness tests. Mechanism analysis reveals that digital transformation reduces ESG decoupling by improving information processing ability and relieving information asymmetry. The relationship between corporate digital transformation and ESG decoupling is stronger among companies in eastern China and firms that do not follow GRI guidance. The economic consequence analysis suggests that corporate digital transformation promotes firms' high-quality development by reducing ESG decoupling. This study helps reveal corporate digital transformation's empowering role and governance role in ESG decoupling and contributes to the growing literature on ESG decoupling and corporate digital transformation.

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Introduction

Environmental, social, and governance (ESG) issues have attracted widespread attention from the practical and academic communities, and firms have disclosed various kinds of ESG reports to satisfy the stakeholders' expectations (Clarkson et al., 2013; Khan et al., 2015). ESG information complements financial statements, releasing altruistic signals about the company and establishing an excellent reputation to stakeholders (Godfrey, 2005). Compared to mandatory financial information, corporate management has more flexibility in preparing ESG information and more discretion in disclosing ESG reports. Management may adopt symbolic misrepresentation tactics or exaggerate ESG performance to enhance legitimacy, resulting in "inconsistency between words and actions" of ESG (Marquis and Qian, 2014). This reporting phenomenon, showing the disparity between external ESG reporting and practical ESG actions, is called ESG decoupling (Delmas and Burbano, 2011; Tashman et al., 2019; Eliwa et al., 2023). Previous studies generally viewed ESG decoupling as an unethical behavior affected by management's egoism (Hawn and Ioannou, 2016), inevitably reducing information transparency and firm value (Du, 2015; García-Sánchez et al., 2021). Hence, how to govern ESG decoupling is an urgent issue attracting growing attention from scholars and firms' stakeholders.

Scholars have identified several determinants of ESG decoupling, including regulatory contexts, market pressures, firm characteristics, corporate governance factors, and individual psychological drivers (Marquis and Qian, 2014; Kim and Lyon, 2015; Luo et al., 2017; Sauerwald and Su, 2019; García-Sánchez et al., 2021; Shahab et al., 2021; Zhang, 2022; Gull et al., 2023; Xia et al., 2023). However, there is still a lack of literature on how to inhibit enterprise ESG decoupling (Velte, 2023), and we know little about the digital technology forces that curb ESG decoupling. With the mass adoption of digital technologies, firms integrate various digital technologies into all parts of their business, so-called corporate digital transformation (Vial, 2019). Digital transformation affects not only firms' production and operation but also corporate information generation and communication (Bertani et al., 2020; De Sousa Jabbour et al., 2018). Taking Big Data technologies as an example, Zhu (2019) argues digital technologies play a governance role in reducing management opportunistic behavior. Therefore, this paper focuses on the digital technology forces and investigates whether corporate digital transformation can restrain ESG decoupling.

The digital technology revolution is powerfully driving socioeconomic development in China. China has a unique political, economic, and cultural environment that has profoundly impacted the development of its emerging digital economy. The Chinese government attaches great importance to digital transformation and innovation, introduces a series of policies and measures to promote the development of the digital economy, and actively explores innovation paths and models suited to its national conditions. For example, the Chinese government issued the Digital Economy Development Strategy Outline, the first overall digital economy strategy at the national level, in 2018. As disclosed in China's Digital Economy Development Report 2023, China made a breakthrough in digital economy development in 2022, touching 50.2 trillion yuan (\$6.9 trillion) and accounting for 41.5% of the country's GDP. In addition, China's 14th Five-Year Plan outlines that digital transformation will drive overall changes in production, lifestyle, and governance, thus elevating digital transformation to a national strategy. The digital economy, driven by social development trends and national policy support, has become an essential pillar of China's economic transformation. Firms implement sustainable digital transformation to adapt to this

changing environment, ensure business continuity, and cope with development crises (Reuschl et al., 2022).

We postulate that corporate digital transformation can restrain ESG decoupling by improving managers' ability to prepare ESG reports and reducing managers' subjective motivation to manipulate ESG reports. Specifically, Digital technologies help firms collect, process, and communicate information (Wu et al., 2021). It will improve firms' internal control and strengthen ESG information quality, consistent with internal control's objective of providing high-quality external reporting in the COSO report. Furthermore, digital transformation increases more stakeholders' monitoring over firms and reduces monitoring costs. Hence, corporate digital transformation may reduce management's engagement in information manipulation and thus restrain ESG decoupling.

Using Chinese A-share listed companies from 2010 to 2019 and adopting the text analysis method to measure corporate digital transformation, this paper examines the nexus between corporate digital transformation and ESG decoupling and finds that corporate digital transformation can substantially alleviate ESG decoupling. Mechanism analysis shows that improving a firm's information processing ability and restraining information asymmetry mediate corporate digital transformation's effect on ESG decoupling. Further research suggests that the relation between corporate digital transformation and ESG decoupling is more pronounced in the firms located in Chinese eastern regions and in firms that do not follow GRI standards. Ultimately, our economic consequence analysis suggests corporate digital transformation helps firms' high-quality development by reducing ESG decoupling.

The contributions of this paper are as follows: first, it contributes to the determinants of ESG decoupling. Existing literature has studied country-specific and firm-specific determinants of ESG decoupling (Velte, 2023), mainly focusing on regulatory/monitoring contexts, market pressures, firm characteristics, corporate governance factors, and individual psychological traits (Marquis and Qian, 2014; Kim and Lyon, 2015; Luo et al., 2017; Sauerwald and Su, 2019; García-Sánchez et al. 2021; Shahab et al., 2021; Zhang, 2022; Gull et al., 2023; Xia et al., 2023). However, few works have studied the role of the technological forces on ESG decoupling. With digital technology's increasing impacts on firms' behavior, whether corporate digital transformation can restrain ESG decoupling and the mechanisms behind it has not yet been answered systematically. In response to Velte's (2023) call for strengthening ESG decoupling research, this paper explores these questions and sheds light on one critical determinant of ESG decoupling, thereby enriching the literature in this field.

Second, this paper enriches and extends the literature on the economic consequences of corporate digital transformation. While previous literature has mainly studied digital empowerment effects from the perspectives of organizational change, organizational performance, and innovation (Vial, 2019; Chouaibi et al., 2022; Gao et al., 2023), this paper investigates the efficacy of digital transformation on ESG decoupling and its mechanisms from the perspective of management information disclosure, which provides an accurate understanding and assessment of corporate digital transformation's social outcomes.

Thirdly, this paper deepens research on the relationship between digital transformation and ESG. Several studies use the Bloomberg ESG score or Huazheng ESG index to proxy for ESG performance and find that firms exhibiting high-level digital transformation increase their ESG performance (Chen and Hao, 2022; Lu et al., 2023; Fang et al., 2023; Wang et al., 2023). We deepen these studies by providing further evidence that digital

transformation improves firms' ESG disclosure quality and promotes consistency in firms' ESG disclosures and ESG activities. We find digital transformation strengthens firms' information processing ability, restrains information asymmetry, and restrains the gap between firms' ESG reporting and ESG activities. Thus, we add to the literature by disentangling ESG disclosure from actual ESG activities and deepening the research on the relationship between digital transformation and ESG.

Prior literature and hypothesis

Literature review

Digital transformation. Digital transformation is a reengineering process that aims to promote operational efficiency and organizational performance via utilizing connectivity, communication, computing, and information technologies (Vial, 2019). Existing research finds that external environmental changes, such as financial support for digital technology, widespread application of next-generation digital technologies, updates to and modification of business model strategy, and the development needs of firms themselves, can stimulate corporate digital transformation (Warner and Wager, 2019; Wu et al., 2021; Verhoef et al., 2021).

A large body of research has focused on the impact of digital transformation on micro-firms. First, digital transformation is a whole-process, all-around management structure transformation that successfully transforms companies' operations (Fitzgerald et al., 2014; Verhoef et al., 2021). Companies have reinvented customer engagement, information, and products and services through new information access, mobility, and interactivity capabilities (Berman, 2012). Digital technologies help create deeper consumer relationships and generate new distribution channels to develop and deliver value to the customer base (Matarazzo et al., 2021). Second, by integrating digital technology into firms' production processes, production intelligence, and automation can reduce labor costs, while applying big data can predict production tasks more accurately and greatly improve productivity (Agrawal et al., 2019; Vial, 2019). Digital transformation can also improve corporate performance through the speed of digital innovation and operational efficiency (Liu et al., 2023a) and enable firms to reduce credit financing costs and have better capital market performance (Wu et al., 2021; Wu et al., 2022; Zhou and Li, 2023). Third, corporate digital transformation increases research and development expenditure and promotes innovation output (Gao et al., 2023). Finally, firms' digital transformation is not smooth, and the "IT paradox" (Ekata, 2012) may raise moral and ethical issues, such as privacy, discrimination, and workers' rights (Etter et al., 2019).

The definition and theory foundation of ESG decoupling. Originating in organization studies, decoupling means the gap between symbolic policy adoption and low-quality implementation (Westphal and Zajac, 2001; Tilcsik, 2010; Luo et al., 2017). Applying the term "decoupling" to the corporate social responsibility (CSR) field, CSR decoupling is defined as the difference between external CSR efforts and internal CSR actions (Sauerwald & Su, 2019; Velte, 2023). ESG decoupling, which emerged with the proliferation of firms' ESG reporting, has received significant academic attention recently (Eliwa et al., 2023; Liu et al., 2023b; Di and Li, 2023). The concept of ESG decoupling is similar to CSR decoupling and greenwashing. However, greenwashing is a decoupling strategy for environmental issues, and CSR decoupling only covers the social and environmental dimensions (Liu et al., 2023b). As ESG also includes governance factors, ESG decoupling is broader than greenwashing and CSR decoupling. Hence, we adopt the broader term ESG decoupling in this context and define ESG decoupling as the gap between external ESG

reporting and practical ESG action (Tashman et al., 2019). We argue that this gap may not necessarily be caused by corporate exaggerated disclosure strategy, and it can also be attributed to factors such as firms' weak information processing capabilities.

The legitimacy theory and asymmetric information theory provide theoretical foundations for ESG decoupling. Legitimacy theory suggests that organizations can gain legitimacy when their actions conform to social norms and principles (Suchman, 1995). Firms demonstrate that they behave in socially recognized, normative manners by disclosing ESG reporting that meets the stakeholders' requirements, hence obtaining social acceptance and achieving legitimacy (Velte, 2023). However, managers may conduct self-impression management and overstate firms' positive ESG image when lacking stakeholders' monitoring. As a result, what companies allege they have done may not accurately reflect the actual situation, and firms can still maintain their legitimacy (Meyer and Rowan, 1977; Talpur et al., 2023).

The asymmetric information theory can theoretically support ESG decoupling. Asymmetric information theory proposes that different individuals have different levels of information in market economy activities, which leads them to occupy different positions in trading or decision-making, thus affecting the normal operation of the market (Akerlof, 1970; Spence 1973; Rothschild and Stiglitz, 1976). Similarly, in the context of ESG reporting, ESG information is voluntarily disclosed and is more challenging to evaluate and monitor than financial information. Moreover, corporate managers have more ESG information than other stakeholders. Therefore, firms may use impression management tactics to misrepresent, disguise, or exaggerate actual ESG performance and disclose information that does not reliably reflect all material aspects of ESG behavior (Tashman et al., 2019; Hawn and Ioannou, 2016), resulting in the more severe problem of information asymmetry in the ESG investment market (Sun et al., 2023). Hence, information asymmetry in ESG reporting can create a gap between corporate ESG reports ("saying") and ESG practices ("doing").

The determinants of ESG decoupling. Some scholars have studied the factors influencing ESG decoupling from multiple aspects. In the realm of regulatory/monitoring contexts influencing ESG decoupling, a synthesis of various studies provides valuable insights. The pervasiveness of a country's institutional voids tends to increase ESG decoupling, while internationalization has the opposite effect (Tashman et al., 2019). Examining the impact of new environmental laws, the study by Zhao et al. (2022) reveals that board network centrality exhibits a positive correlation with over-decoupling in the pre-adoption period (2009–2014) but a negative correlation in the post-adoption period (2015–2018). Besides, a country's absence of political rights and cross-listings reduces ESG decoupling, while a higher country corruption index increases ESG decoupling tendencies (Yu et al., 2020). Additionally, firms are more inclined to implement substantive ESG practices where external monitoring is expected, and external deregulation increases ESG decoupling (Marquis and Qian, 2014; Kim and Lyon, 2015).

Many scholars have studied the determinants of ESG decoupling from market pressure. Arouri et al. (2021) find that product market competition negatively impacts ESG decoupling, particularly when firms bear substantial environmental costs. Zhang (2022) documents that high analyst coverage increases a company's visibility and helps mitigate information asymmetries between stakeholders and the company, thereby significantly reducing ESG decoupling. Furthermore, applying the GRI guidelines and ESG reporting assurance enhances the credibility of ESG reporting and reduces ESG symbolic practices (García-Sánchez et al., 2022).

The influence of firm characteristics on ESG decoupling has also attracted much attention from scholars. Following engagements with UNGC, private firms significantly reduce their negative ESG incident levels, while public firms fail to do so and are more likely to engage in symbolic ESG action (Li and Wu, 2020). Family ownership appears to be associated with lower ESG decoupling, mainly because they make decisions based on accumulated emotional legacy or socio-emotional wealth and are more ethical when informing stakeholders of their commitment to ESG (Parra-Domínguez et al., 2021). Furthermore, firms that are more environmentally damaging, particularly those in countries that are more exposed to scrutiny and global norms, are less likely to engage in greenwashing (Marquis et al., 2016).

Research on the relationship between corporate governance and ESG decoupling has also yielded valuable insights. CSR board committees have been found to mitigate ESG decoupling. Specifically, larger CSR committee size, greater independence of committee members, and longer member tenure have been associated with reduced ESG decoupling (Gull et al., 2023). Similarly, Eliwa et al. (2023) found that firms with a more gender-diversified board of directors tend to engage less in ESG decoupling.

The research on individual psychology of management also complemented the study on determinants of ESG decoupling. Overconfident CEOs may exaggerate the perceived ability to affect ESG initiatives, leading them to disclose ESG information in an overly optimistic manner, and more powerful CEOs focus on short-term benefits, all of which exacerbate ESG decoupling (Shahab et al., 2021; Sauerwald and Su, 2019). Narcissistic CEOs are more inclined to pay attention to externally oriented ESG activities rather than internal guidance of ESG activities (Al-Shammari et al., 2019). In addition, entrenched managers tend to decouple ESG disclosure and performance (García-Sánchez et al., 2020).

Existing studies have examined the influencing factors of ESG decoupling from the perspectives of the monitoring context, market pressure, firm characteristics, corporate governance, individual psychology, etc. However, there are still several unresolved issues in the existing literature. First, few works have explored the mechanism of governing ESG decoupling from the technological perspective. Although a few articles have investigated the relationship between digital transformation and ESG performance (Chen and Hao, 2022; Lu et al., 2023; Fang et al., 2023; Wang et al., 2023), existing research on the impact of digital technology on corporate ESG decoupling is still scarce, with only fintech and digital transformation on corporate greenwashing (Xie et al., 2023; Sun et al., 2023). With digital technology's increasing influence on firms' behavior, whether corporate digital transformation can restrain ESG decoupling and its mechanisms have not been answered systematically.

Second, most studies use two external ESG databases to measure ESG decoupling, while strong interdependencies exist between these databases. For example, the Asset4 database (to calculate ESG performance) also analyzes ESG reports, while the Bloomberg database (to measure ESG reporting) also includes ESG performance measures (Velte, 2023). According to Velte's (2023) critique of existing decoupling variable measurement, we follow his suggestion and adopt automated textual analysis of ESG reports to deduce ESG decoupling proxies.

Third, existing research considers ESG decoupling to be primarily managers' impression management behavior, ignoring the fact that it may also be a limitation of managers' information gathering and information analysis capabilities, which leads to an overly optimistic portrayal of a firm's actual ESG performance, resulting in ESG decoupling. Just as optimistically-biased management earnings forecast serves as a proxy for the

management forecast quality (Hirst et al., 2008), ESG decoupling can also be a vital proxy for ESG reporting quality. Hence, based on the information quality view of ESG decoupling, the existing literature falls short of studies that analyze ESG decoupling from the perspective of information inputs.

Our study explores the impact of digital transformation on ESG decoupling. We propose corporate digital transformation strengthens firms' information processing ability and restrains information asymmetry, hence narrowing the gap between firms' ESG reporting and ESG activities. Our paper investigates the mechanism of governing ESG decoupling from the technological perspective, adopts an automated textual analysis method to measure ESG decoupling, and considers ESG decoupling from both the impression management perspective and the information quality view, thereby supplementing the existing literature.

Research hypothesis. Corporate digital transformation improves firms' ability to collect, process, and deliver ESG information, which restrains ESG decoupling from the input perspective of the ESG reporting process. Digital technologies can enhance corporate internal control (Liu et al., 2022). Internal control is a formal framework for producing firms' reporting, which considers providing high-quality information one of its main objectives and generally includes some essential elements (Garrett et al., 2014). For example, the COSO framework is a widely accepted internal control guidance emphasizing managing various financial and non-financial reporting risks. ESG reports, also called CSR reports, environmental reports, sustainability reports, and so on, fall into the non-financial reporting category. Digital transformation can improve corporate internal control, mainly by enhancing the speed of information collection, expanding the scope of information collection, reducing the cost of information processing, and improving the accuracy and reliability of information (Chen and Hao, 2022). As a result, when managers' ability to access information improves, they will likely be less blind and optimistic in drafting ESG reports.

The empowering effect of corporate digital transformation is mainly focused on information and communication, which is the crucial element of the internal control system. Digital technologies enhance firms' open and clear communication and data collecting (Matarazzo et al., 2021). They enable companies to disclose timelier, more accurate information and better fit stakeholders' information needs. Digital transformation facilitates the exchange of information and resources between companies and the outside; enhances connections, communication, and cooperation between companies and upstream or downstream companies (Correani et al., 2020; Vial, 2019); improves management's perceptual capabilities to identify, develop, and evaluate technological opportunities regarding customer needs (Tece, 2007); and helps create new services or products tailored to client requirements and optimize customer experience (Vial, 2019). Effective internal control makes ESG disclosures more consistent with actual activities. Therefore, corporate digital transformation can enhance internal control levels and provide a guarantee to mitigate ESG decoupling.

Corporate digital transformation can reduce management's subjective motivations for information disclosure manipulation, which restrains ESG decoupling from the output's perspective of the ESG reporting process. Based on agency theory, information asymmetry between firms and stakeholders is an important driver of ESG decoupling (Velte, 2023). Digital transformation can reduce information asymmetry between firms and stakeholders and enhance corporate information transparency (Zhong et al., 2023). With the guidance of national policies, companies that undergo digital transformation gain more market attention,

increasing analyst attention and media coverage (Wu et al., 2021). Hence, digital transformation enhances stakeholders' monitoring over firms. In addition, digital transformation makes companies' production and operation processes more transparent and thus reduces external supervision costs (Goldfarb and Tucker, 2019). It enables external monitors to verify a firm's ESG information at a lower cost, thereby improving the effectiveness of stakeholders' monitoring. Meanwhile, digitalization inhibits organizational centralization and promotes decentralization at the grassroots level (Adner et al., 2019), weakening management's discretion. These changes in internal and external factors indicate that corporate digitization can significantly reduce managers' opportunism behavior and tendency to manipulate information disclosure. Reducing disclosure manipulation helps align ESG reporting with its actual performance.

Given the theoretical analysis above, corporate digital transformation can improve ESG reports' quality through the information process's inputs and outputs, reduce management's over-optimism and exaggeration of ESG information, and thus curb ESG decoupling. Hence, we propose the following conjecture:

H1: Corporate digital transformation significantly mitigates ESG decoupling.

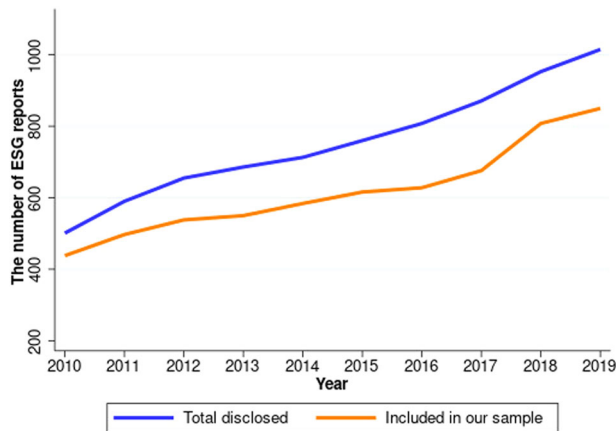


Fig. 1 The number of ESG reports by year. This figure shows the trend of total ESG reports disclosed by China's listed companies, marked in blue colors. Orange line is the number of ESG reports used in our analysis. Both lines show that the number of ESG reports has increased significantly from 2010 to 2019.

Research design

Data and sample. This paper focuses on publicly traded firms in Shanghai and Shenzhen A-shares that disclosed ESG reports from 2010 to 2019. In addition, this paper deletes the following observations: financial and insurance industry samples, the ST, *ST, and PT companies, and observations missing data used in the regression model. After the above processing, we obtain 6185 observations. We winsorize all the continuous variables at 1% and 99% quartiles to eliminate the influence of extreme values. The data on corporate digital transformation is derived from the CSMAR database. Data on degrees of corporate digital transformation are obtained manually through text analysis. ESG decoupling includes two parts of data: data measuring ESG disclosure are manually collected from independent ESG reports, and the data measuring actual ESG performance are obtained from the CNRDS database. Other data come from the CSMAR database.

A company may provide social and environmental data in its CSR reports, sustainable development reports, sustainability reports, and ESG reports, and this can be seen as an aspect of a business being a corporate citizen that receives benefits from, and therefore owes duties back to, society. Following Gillan et al. (2021) and Tsang et al. (2023), we treat these reports without distinction and refer to them collectively as ESG reporting. As ESG issues have attracted widespread attention from firm stakeholders, more and more listed companies in China have begun to disclose ESG reports. As shown in Fig. 1, the number of ESG reports has increased significantly from 438 in 2010 to 850 in 2019, which is consistent with the existing literature (He et al., 2022).

Model and variable definition. Following Zhang (2022) and Wu et al. (2021), we construct the following model (1) to test our hypothesis H1.

$$Decoupling = \alpha_0 + \alpha_1 Digital + \alpha_2 \sum Controls + \sum Year + \sum Industry + \epsilon \tag{1}$$

In model (1), the dependent variable is ESG decoupling (*Decoupling*), and the core independent variable is corporate digital transformation (*Digital*). A battery of control variables is added to the model. We expect to find a negative α_1 if hypothesis H1 is supported. Table 1 outlines the definitions of the variables.

ESG decoupling. Following existing studies (Sauerwald and Su, 2019; Zhang, 2022), we define ESG decoupling as the gap between the optimistic tone of corporate ESG reports and actual ESG performance. We use metrics to measure ESG reporting's optimistic tone through text-content analysis (Tetlock et al., 2008; Arslan-Ayaydin et al., 2016). The optimistic tone vocabulary was

Table 1 Variables definition.

Variable Name	Variable	Variable Definition
ESG Decoupling	<i>Decoupling</i>	The gap between the optimistic tone of the ESG disclosure and ESG practices
Corporate digital transformation	<i>Digital</i>	Natural log of digital technology words' frequency
Financial leverage ratio	<i>Lev</i>	Year-end liabilities/Year-end assets
Return on Net Assets	<i>ROE</i>	Net income/owner's equity
Firm size	<i>Size</i>	The natural logarithm of the company's employees at the end of the year
Firm Age	<i>Age</i>	Current Year - Year of Establishment
Firm Growth	<i>Growth</i>	Operating income growth rate
Percentage of the largest shareholder's stockholding	<i>First</i>	Number of the largest shareholder's shares / total number of firm's shares
CEO/Chair Duality	<i>Dual</i>	The chairman and CEO are the same person denoted as 1, otherwise 0
Board size	<i>DirNum</i>	Number of board directors
State-owned enterprise	<i>SOE</i>	State-controlled firms denote as 1, otherwise 0
Institutional investors' shareholding ratio	<i>Inst</i>	Number of shares held by institutional investors/total number of shares

Table 2 Descriptive statistics.

Variables	Obs	Mean	SD	Min	Median	Max
Decoupling	6185	0.0483	1.5087	-3.9391	0.0985	3.2777
Digital	6185	1.1590	1.3234	0.0000	0.6931	4.9904
Lev	6185	0.4820	0.1988	0.0625	0.4926	0.8755
ROE	6185	0.0878	0.1065	-0.4078	0.0860	0.3794
Size	6185	23.0860	1.4210	20.3672	22.9474	26.9732
Age	6185	17.4598	5.5023	4.0000	17.0000	31.0000
Growth	6185	0.1439	0.2224	-0.2315	0.0962	1.2671
Dual	6185	0.1840	0.3875	0.0000	0.0000	1.0000
First	6185	0.3762	0.1595	0.0784	0.3663	0.7572
DirNum	6185	10.1182	2.9412	4.0000	10.0000	19.0000
Inst	6185	0.4924	0.2263	0.0069	0.5187	0.9079
SOE	6185	0.5887	0.4921	0.0000	1.0000	1.0000

Table 3 Univariate analysis: grouped by whether a firm performs digital transformation.

Variables	No digital transformation		Digital transformation		Difference t test
	Obs	Mean	Obs	Mean	
Decoupling	2101	0.1887	4084	-0.0239	0.2126***
Lev	2101	0.4916	4084	0.4771	0.0145***
ROE	2101	0.0877	4084	0.0879	-0.0001
Size	2101	22.8742	4084	23.1950	-0.3208***
Age	2101	16.1195	4084	18.1494	-2.0299***
Growth	2101	0.1462	4084	0.1428	0.0034
Dual	2101	0.1456	4084	0.2037	-0.0581***
First	2101	0.3901	4084	0.3690	0.0211***
DirNum	2101	9.8653	4084	10.2483	-0.3830***
Inst	2101	0.4872	4084	0.4951	-0.0079
SOE	2101	0.6901	4084	0.5365	0.1537***

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. T-statistic values are means tests for the sub-group without digital transformation versus those with digital transformation.

judged using a word list developed and validated by Loughran and McDonald (2011). The optimistic tone is the number of positive words minus the negative word count divided by the sum of the positive and negative words in the ESG report, multiplied by 100 to yield a percentage interpretation (Blau et al., 2015). The ESG rating score from the CNRDS database, a third-party agency that rates listed companies' ESG performance, measures corporate ESG performance. Then, we convert optimistic tone and ESG performance to z-scores to make them comparable. ESG decoupling is then calculated as converted optimistic tone minus ESG performance scores, and the larger the difference, the greater the decoupling between disclosed ESG and practical ESG activities (Sauerwald and Su, 2019).

Corporate digital transformation. Referring to Wu et al. (2021), Wu et al. (2022), and Zhou and Li (2023), we construct a digital transformation dictionary and adopt the textual analysis approach to measure a firm's digital transformation degree. To construct the digital terminology dictionary, we first obtain several important national-level policy documents, important news and meetings, and recent government work reports related to the digital economy between 2010 and 2019. Then, we use Python word segmentation processing and manual recognition, and select the words pertaining to corporate digitalization with a frequency greater than or equal to 5 times to constitute a digital terminology dictionary. Finally, these words are classified into five categories:

artificial intelligence technology, big data technology, cloud computing technology, blockchain technology, and digital technology application. The specific words included in the digital transformation dictionary are shown in Appendix A. To measure a firm's digital transformation, we adopt machine learning method to analyze the text of the "Management Discussion and Analysis" (MD&A) part of the annual report, calculate the frequencies of keywords that appeared in our digital transformation dictionary, and then add them up. The greater the value of the frequencies of keywords, the higher the corporate digital transformation.

Control variables. Drawing upon literature such as Sauerwald and Su (2019), Zhang (2022), and Wan et al. (2024), this paper controls for the following variables: financial leverage ratio (*Lev*), return on net assets (*ROE*), firm growth (*Growth*), firm age (*Age*), firm size (*Size*), CEO/Chair duality (*Dual*), board size (*DirNum*), largest shareholder's stockholding ratio (*First*), institutional investors' shareholding ratio (*Inst*), and state-owned enterprise (*SOE*).

Empirical results and analysis

Descriptive statistics. Table 2 summarizes the descriptive statistics of the main variables. The mean value of ESG decoupling (*Decoupling*) in the sample is 0.0483, which indicates that ESG disclosure is more than the actual fulfillment, and there is general inconsistency between ESG words and actions. The standard deviation of *Decoupling* is 1.5087, suggesting ESG decoupling varies considerably between companies. The mean value of digital transformation (*Digital*) is 1.159, the minimum value is 0, the median value is 0.693, and the maximum value is 4.990, indicating that the degree of digital transformation varies widely among listed firms. Most firms' digital transformation values are lower than the average in China, consistent with the results of Wu et al. (2021).

Univariate analysis. Table 3 reports the results of the univariate test. The mean value of ESG decoupling (*Decoupling*) is 0.189 for firms that did not undergo digital transformation and -0.024 for firms that conducted digital transformation. The difference between the two groups is significantly negative at $p < 0.01$, indicating significantly different ESG decoupling in the two sub-groups. Regarding the control variables, the mean values of financial leverage ratio (*Lev*), top shareholder ownership (*First*), and state-owned enterprise (*SOE*) are significantly higher for companies without digital transformation than for companies with digital transformation. In comparison, the mean values of firm size (*Size*), firm age (*Age*), CEO/Chair duality (*Dual*), and number of board directors (*DirNum*) for companies without

Table 4 Baseline regression results.

Variables	(1)	(2)
Digital	-0.1868*** (-9.5435)	-0.1168*** (-6.0778)
Lev		0.2162* (1.6890)
ROE		0.0166 (0.0842)
Size		-0.3268*** (-17.7119)
Age		0.0114*** (2.8181)
Growth		0.0103 (0.1143)
Dual		0.0599 (1.2047)
First		0.0923 (0.6669)
DirNum		-0.0255*** (-3.7832)
Inst		-0.0988 (-0.9763)
SOE		0.2820*** (6.0514)
Constant	0.7791*** (4.3825)	7.7624*** (19.0219)
Year	Yes	Yes
Industry	Yes	Yes
N	6185	6185
R-square	0.0705	0.1384

Robust t-statistics in parentheses; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Same below.

Table 5 Results of an instrumental variable method test.

Variables	Digital	Decoupling
Predicted_Digital		-2.3941*** (-3.3036)
IV_1984	0.0628*** (3.6963)	
Lev	-0.1300 (-1.4794)	-0.1175 (-0.4497)
ROE	0.3557*** (2.6414)	0.9361** (2.0732)
Size	0.1388*** (10.9227)	-0.0093 (-0.0850)
Age	-0.0028 (-1.0165)	0.0024 (0.2980)
Growth	0.1555** (2.5466)	0.3044 (1.5038)
Dual	-0.0019 (-0.0555)	0.0373 (0.3938)
First	-0.2531*** (-2.6497)	-0.4415 (-1.4310)
DirNum	0.0002 (0.0464)	-0.0280** (-2.1886)
Inst	-0.0983 (-1.4086)	-0.3409* (-1.7531)
SOE	-0.2124*** (-6.6683)	-0.1649 (-0.9106)
Constant	-3.2039*** (-10.0759)	1.5963 (0.7815)
Year	Yes	Yes
Industry	Yes	Yes
N	5856	5856
Kleibergen-Paap rk LM statistic		14.532***
R-square	0.5127	-

digital transformation are significantly lower than for companies with digital transformation, indicating significant differences in the characteristics of the two sub-groups.

Baseline regression analysis. Table 4 shows the results of the baseline regressions. Column (1) shows that the coefficient of digital transformation is significantly negative at $p < 0.01$ without controlling for the control variables. Column (2) shows that the coefficient on digital transformation is -0.1168 and significantly negative at $p < 0.01$ after controlling for the control variables. In terms of economic magnitude, for a one-unit standard deviation increase in corporate digital transformation, ESG decoupling will decrease by 15.46%, indicating that a higher degree of corporate digital transformation leads to less disconnect between “words and deeds” on ESG. This empirical result suggests that corporate digital transformation plays a governance role in ESG decoupling. Thus, our hypothesis H1 is supported.

Regarding control variables, financial leverage ratio (Lev), firm age (Age), and state-owned enterprise (SOE) are significantly and positively related to ESG decoupling. In contrast, firm size (Size) and number of board directors (DirNum) are significantly and negatively associated with ESG decoupling. The results for the control variables are consistent with previous studies (Zhang, 2022; Sauerwald and Su, 2019). The baseline results indicate that the governance role of digital transformation in ESG decoupling can complement the governance mechanisms found in previous literature (Gull et al., 2023; Zhang, 2022). It can also provide a new approach for management and external regulators who aim to reduce the degree of ESG decoupling. Utilizing digital technologies to set up an effective internal control system for ESG governance and establish an externally efficient and

intelligent ESG disclosure monitoring platform are essential for maximizing the governance efficacy of digital transformation on ESG decoupling.

Endogeneity

2SLS regression method. The effect of a firm’s digital transformation on ESG decoupling may suffer the endogeneity problem. We adopt the 2SLS regression method to alleviate this concern. Drawing on Xiao et al. (2022), we select the interaction term between each city’s post and telecommunications data in 1984 and the number of Internet users nationwide with a one-year lag as the instrumental variable of firm digital transformation. The means of communication adopted in a region affect a firm’s acceptance and application of information technology through technological capability, satisfying the correlation requirements of instrumental variables. Meanwhile, posts and telecommunications are mainly infrastructure for communication services and do not directly contribute to ESG decoupling, satisfying the exogeneity requirement. Specifically, referring to Nunn and Qian (2014), we first figure the product of the number of national internet users in the previous year and the number of fixed telephones per 10,000 people in 1984 in the prefecture city where the firm is located and then calculate the natural log value of the product as the instrumental variable (denoted as *IV_1984*).

Column (1) of Table 5 shows that the regression coefficient of the instrumental variable (*IV_1984*) is significantly positive at the 1% level in the first stage regression, indicating that the instrumental variable is significantly associated with the independent variable. The Kleibergen-Paap rk LM statistic is 14.532, rejecting the instrumental variable’s under-identified hypothesis. The F statistic is 13.663, which is greater than the thumb-rule value of 10, indicating no significant weak instrumental variable

Table 6 Heckman two-stage regression results.

Variables	(1) Treat	(2) Decoupling
Digital		-0.1130*** (-4.9995)
Lev	-0.1346 (-0.9261)	0.0803 (0.4874)
ROE	0.0986 (0.4242)	-0.0701 (-0.2744)
Size	0.2031*** (9.8427)	-0.3904*** (-15.8076)
Age	-0.0089* (-1.8673)	0.0114** (2.3797)
Growth	-0.0479 (-0.4402)	0.0495 (0.4266)
Dual	-0.0432 (-0.7402)	0.0868 (1.5111)
First	0.0217 (0.1357)	-0.0056 (-0.0311)
DirNum	0.0063 (0.8108)	-0.0294*** (-3.4848)
Inst	0.2411** (2.1036)	0.0205 (0.1560)
SOE	-0.4104*** (-7.8156)	0.3511*** (5.6477)
IMR		0.2973* (1.9039)
Constant	-4.9121*** (-10.9467)	8.7364*** (14.0656)
Year	Yes	Yes
Industry	Yes	Yes
N	6155	4056
R-square	0.3546	0.1739

problem, which supports the rationality of the instrumental variables selected in this paper. Column (2) shows that instrumented digital transformation (denoted as *Predicted_Digital*) is negatively associated with ESG decoupling at the 1% level, indicating that the main conclusion of our paper still holds after alleviating the potential endogeneity problem.

Heckman two-stage regression. Digital transformation is a strategic choice firms make in response to external environment changes, and hence, our study may suffer a self-selection problem. This paper uses a Heckman two-stage regression to mitigate potential sample selection bias (Heckman, 1979). In the first stage, the dummy variable of whether a firm undergoes digital transformation (denoted as *Treat*) is constructed as the explanatory variable. Considering that industry characteristics, firm characteristics, and executive factors may influence firms' digital transformation, all control variables used in the baseline regression are included in the Probit regression, and then we estimate the probability of a firm undergoing digital transformation and obtain the inverse Mills ratio (*IMR*). *IMR* is added to the original model (1) as a control variable for the second-stage regression. Column (2) in Table 6 shows that the regression coefficient of digital transformation (*Digital*) is still significantly negative after adding *IMR*, suggesting that digital transformation's effect on ESG decoupling remains robust.

PSM method. To further address sample bias, this paper uses the Propensity Score Matching (PSM) method to alleviate the endogeneity concern. We classify firms that did not implement digital transformation as the control group (*Treat* = 0) and those that implemented digital transformation as the treatment group

Table 7 PSM test results.

Variables	Decoupling
Digital	-0.1077*** (-4.1464)
Lev	0.3922*** (2.8159)
ROE	-0.0453 (-0.2043)
Size	-0.2470*** (-11.9703)
Age	0.0058 (1.2964)
Growth	-0.0571 (-0.5821)
Dual	0.1698*** (3.0573)
First	0.0172 (0.1145)
DirNum	0.0105 (1.3644)
Inst	0.0734 (0.6689)
SOE	0.0782 (1.4712)
Constant	5.5208*** (11.5800)
Year	Yes
Industry	Yes
N	4679
R-square	0.1053

(*Treat* = 1). All the control variables used in our baseline regression were selected as covariates. We formed the test sample according to the nearest approach matching method in the 1:3 caliper with return. After matching, the standardized variation of each covariate is less than 10%, indicating no significant difference between the covariates of the treatment and control groups, which satisfies the equilibrium hypothesis. Table 7 shows the results of regression using matched samples. After controlling for differences in essential characteristics at the firm level, corporate digital transformation (*Digital*) negatively relates to ESG decoupling, indicating that the baseline regression findings are still robust.

Robustness tests

Alternative measurement of corporate digital transformation. Referring to Li et al. (2023), this paper uses the proportion of digital economy-related intangible assets to total assets in the breakdown of a firm's intangible assets as an alternative measurement for corporate digital transformation (*Digital₁*). Digital economy-related intangible assets refer to line items including "intelligent platform," "management system," "client," "network," "software," and other digital technology-related keywords, as well as related patents. Column (1) in Table 8 shows *Digital₁* negatively restrains ESG decoupling at *p* < 0.05, indicating that the findings of the baseline regression still hold.

Alternative measurements of ESG decoupling. ESG decoupling is the gap between the optimistic tone of ESG reporting and ESG performance. Here, we change the calculation of optimistic tone in ESG reporting and the proxy of ESG performance to obtain alternative ESG decoupling measurements. First, the calculation of optimistic tone in ESG reporting is changed as the number of positive words minus the negative word count scaled by the total number of words in the ESG report (Tetlock et al., 2008; Blau

Table 8 Alternative measurements of corporate digital transformation and ESG decoupling.

Variables	(1) Decoupling	(2) Decoupling ₁	(3) Decoupling ₂
Digital		-0.1313*** (-6.2592)	-0.0611*** (-3.2600)
Digital _t	-0.2515** (-2.4132)		
Lev	0.2322* (1.8093)	0.2115 (1.5617)	0.1508 (1.2082)
ROE	-0.0263 (-0.1329)	0.2246 (1.0646)	0.1390 (0.7221)
Size	-0.3447*** (-18.7906)	-0.3101*** (-15.7423)	-0.3522*** (-19.5771)
Age	0.0121*** (2.9841)	0.0136*** (3.1057)	0.0098** (2.4734)
Growth	0.0037 (0.0413)	-0.0004 (-0.0043)	0.0742 (0.8443)
Dual	0.0579 (1.1611)	0.0993* (1.8577)	0.1224** (2.5264)
First	0.1326 (0.9551)	-0.0157 (-0.1068)	-0.0034 (-0.0256)
DirNum	-0.0253*** (-3.7359)	-0.0240*** (-3.2915)	-0.0305*** (-4.6457)
Inst	-0.0922 (-0.9089)	-0.2802*** (-2.6154)	-0.2387** (-2.4202)
SOE	0.3034*** (6.5162)	0.2083*** (4.1990)	0.0711 (1.5649)
Constant	8.0784*** (19.8601)	7.4784*** (17.2600)	8.8347*** (22.2029)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
N	6185	5280	6185
R-square	0.1341	0.1372	0.1896

Table 9 Extending observation window.

Variables	(1) Decoupling	(2) Decoupling
Digital_lag1	-0.1315*** (-5.9549)	
Digital_lag2		-0.1462*** (-5.8560)
Lev	0.2257 (1.5697)	0.1936 (1.2248)
ROE	0.0570 (0.2556)	0.1464 (0.6031)
Size	-0.3301*** (-15.9964)	-0.3408*** (-15.0263)
Age	0.0103** (2.2701)	0.0076 (1.5125)
Growth	-0.0445 (-0.3812)	-0.0341 (-0.2651)
Dual	0.0972* (1.7278)	0.1321** (2.1078)
First	0.0228 (0.1414)	-0.0055 (-0.0300)
DirNum	-0.0243*** (-3.2824)	-0.0186** (-2.3042)
Inst	-0.1783 (-1.4645)	-0.2300 (-1.6356)
SOE	0.2854*** (5.5414)	0.2719*** (4.8169)
Constant	8.0706*** (17.6589)	8.4149*** (16.7260)
Year	Yes	Yes
Industry	Yes	Yes
N	4977	4117
R-square	0.1449	0.1525

et al., 2015). We still obtain ESG performance from the CNRDS database, convert optimistic tone and ESG scores to z-scores, and construct the first alternative measure of ESG decoupling (Decoupling1). Second, the way we calculate the optimistic tone in ESG reports does not change, and we derive ESG scores from the RKS rating agency as the proxy of the firm’s ESG performance. Then, we convert the optimistic tone in ESG reports and ESG scores to z-scores and construct another measurement of ESG decoupling (Decoupling2). Columns (2) and (3) of Table 8 report the regression results using alternative measures of ESG decoupling. We can see that the association between digital transformation and ESG decoupling remains significantly negative at the 1% level, suggesting that the primary relationship in our baseline regression still holds.

Extending the observation window. There may be a hysteresis effect on the impact of corporate digital transformation on ESG decoupling. Thus, this paper extends the observation window to test the robustness of our main findings. Specifically, we construct one-year and two-year lags of corporate digital transformation (denoted as *Digital_lag1* and *Digital_lag2*). Table 9 shows the results. The effects of digital transformation on ESG decoupling are all significantly negative at the 1% level, indicating that the time window extension does not attenuate the impact of digital transformation on ESG decoupling and further supporting the baseline regression.

Excluding explanations of corporate strategic disclosure. This paper measures corporate digital transformation via textual analysis methods. Although the indicators more comprehensively capture

firms’ actual use of digital technologies, they may also be exaggerated by firms’ strategic information disclosure. To exclude this possible explanation, we conduct the following tests. First, considering that many listed companies belong to high-tech enterprises and have connections with the Internet and Internet business models, we exclude the high-tech listed companies from the sample. Second, drawing on Xiao et al. (2022), we construct a model to estimate a firm’s normal number of disclosures of digitization-related terms and conclude that the residuals less than or equal to 0 are more likely to be normal disclosures, and those greater than 0 are more likely to be exaggerated disclosures; thus, we eliminate observations with residuals greater than 0. Third, we exclude from the sample companies that the Shenzhen Stock Exchange, the Shanghai Stock Exchange, or the China Securities Regulatory Commission (CSRC) punished for information disclosure during the sample period. Lastly, we retain only those firms with excellent or good information disclosure assessment results from the Shenzhen Stock Exchange and Shanghai Stock Exchange, which are less likely to disclose information strategically. As reported in Table 10, all the digital transformation (Digital) coefficients are negative at the 1% statistical level after controlling for potential strategic disclosure behavior, suggesting that the firm’s strategic disclosure behavior does not affect our primary relationship.

Missing variable test. Although baseline regression includes a range of control variables, important digital transformation and ESG decoupling variables may still be left out, such as the provincial digital environment over time. This paper further incorporates the province-year joint fixed effect to absorb the influence of unobservable factors at the regional level over time. As shown in Table 11, the regression coefficient of digital transformation is

Table 10 Excluding the effect of corporate strategic disclosure.

Variables	(1) Not high-tech enterprises	(2) Normal disclosure	(3) Non-punished firms	(4) Good disclosure
Digital	-0.1136*** (-5.5624)	-0.1344*** (-7.7731)	-0.1094*** (-4.4872)	-0.1229*** (-5.8215)
Lev	0.1967 (1.4607)	0.1903* (1.6802)	0.1665 (0.9264)	0.1682 (1.2109)
ROE	0.0326 (0.1564)	0.1131 (0.6581)	0.1136 (0.3948)	0.1341 (0.5958)
Size	-0.3343*** (-17.4927)	-0.3819*** (-24.5360)	-0.3688*** (-13.8691)	-0.3232*** (-16.2886)
Age	0.0118*** (2.7497)	0.0103*** (2.9499)	0.0106** (1.9893)	0.0119*** (2.6998)
Growth	0.0434 (0.4407)	-0.0752 (-0.9359)	-0.0562 (-0.4830)	0.0469 (0.4776)
Dual	0.1073** (2.0197)	0.1364*** (3.1174)	0.1234** (1.9812)	0.0562 (1.0260)
First	0.0880 (0.6119)	0.1086 (0.9034)	0.2129 (1.1542)	0.0318 (0.2125)
DirNum	-0.0230*** (-3.2943)	-0.0228*** (-3.8045)	-0.0374*** (-4.2452)	-0.0306*** (-4.1692)
Inst	-0.0587 (-0.5523)	-0.2252*** (-2.5995)	0.1389 (1.0161)	-0.1171 (-1.0723)
SOE	0.2880*** (5.9800)	0.3098*** (7.2048)	0.3651*** (5.7218)	0.3160*** (6.1894)
Constant	7.9118*** (18.7844)	7.7082*** (22.0527)	8.6444*** (14.7746)	7.7552*** (17.4833)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	5803	3051	3198	5322
R-square	0.1346	0.3739	0.1920	0.1431

significantly negative at the 5% level after controlling the province-year fixed effect, indicating that digital transformation’s enabling and governance role on ESG decoupling still works.

Further analysis

Mechanism test. In conjunction with the notion that corporate digital transformation restrains ESG decoupling from the inputs and outputs perspective of the ESG reporting process, this section will focus on examining the potential mechanisms: whether digital transformation reduces ESG decoupling by improving internal control quality (a proxy for the input perspective) and reducing information asymmetry (a proxy for the output perspective). According to the above theoretical analysis, on the one hand, corporate digital transformation improves internal control by optimizing internal control and thus enhances ESG information disclosure quality. On the other hand, digital transformation decreases information asymmetry by restraining managers from manipulating information disclosure, narrowing the differences in ESG talk and walk. Following Baron and Kenny (1986) and Liu et al. (2021), we construct the following models to examine the mediating role of internal control and information asymmetry.

$$Icw/EM = \delta_0 + \delta_1 Digital + \delta_2 Controls + \sum Industry + \sum Year + \epsilon \tag{2}$$

$$Decoupling = \beta_0 + \beta_1 Digital + \beta_2 Icw/EM + \beta_3 Controls + \sum Industry + \sum Year + \epsilon \tag{3}$$

In model (2), δ_1 measures the magnitude of the efficacy of digital transformation on internal control (denoted as *Icw*) and information asymmetry (denoted as *EM*), respectively. Internal

Table 11 Missing variable test.

Variables	Decoupling
Digital	-0.0424** (-2.0184)
Lev	-0.2145 (-1.3929)
ROE	-0.0619 (-0.3164)
Size	-0.3027*** (-12.4141)
Age	0.0043 (0.9421)
Growth	0.1569* (1.7745)
Dual	0.0456 (0.8767)
First	0.2340 (1.3471)
DirNum	-0.0303*** (-4.1579)
Inst	0.1372 (1.2236)
SOE	0.0839 (1.3347)
Constant	6.0838*** (9.4150)
Year	Yes
Industry	Yes
Province × Year	Yes
N	6185
R-squared	0.4363

control quality (*Icw*) is measured as a composite index of internal control obtained from the Diebold database. Referring to Roychowdhury (2006), information asymmetry (*EM*) is measured by the degree of a firm’s actual earnings management. In model (3), β_1 measures the efficacy of Digital on ESG decoupling after considering the mediating impact of internal control (*Icw*) and information asymmetry (*EM*).

Table 12 shows the results of the mechanical test. In Column (1), digital transformation (*Digital*) is positively associated with internal control quality at the 1% level. Column (2) shows that the coefficient of internal control (*Icw*) is significantly negative at the 10% level, indicating that improving internal control mitigates ESG decoupling, and the coefficient of digital transformation (*Digital*) is still significantly negative, suggesting a partial mediating effect exists. Column (3) demonstrates that digital transformation (*Digital*) negatively relates to earnings management at the 1% level. Column (4) indicates that *EM* has a significantly positive influence on ESG decoupling, and the coefficient of digital transformation (*Digital*) is still significantly negative, indicating a partial mediation effect of *EM*. These results suggest that corporate digital transformation can alleviate ESG decoupling by enhancing internal control quality and reducing information asymmetry, which further supports our hypothesis H1. To communicate ESG information externally accurately, firms need to aggregate their ESG data appropriately (input perspective). Subsequently, they must accurately and impartially summarize and report ESG information (output perspective). Our findings confirm that digital transformation enhances a company’s capabilities in information input and output processes, thereby alleviating ESG decoupling. This indicates that the systematic and comprehensive upgrading goals of digital transformation for organizational activities and processes significantly influence various aspects of businesses. Firms require

Table 12 The mechanism test.

Variables	(1) lcw	(2) Decoupling	(3) EM	(4) Decoupling
Digital	0.0482*** (3.1248)	-0.1146*** (-5.8694)	-0.0082*** (-3.3447)	-0.1080*** (-5.3162)
lcw		-0.0310* (-1.8967)		
EM				0.5030*** (4.5478)
Lev	-1.0032*** (-9.7468)	0.1606 (1.2241)	0.1548*** (9.4966)	0.0887 (0.6484)
ROE	4.2680*** (26.9154)	0.1239 (0.5837)	-0.5798*** (-23.0558)	0.2570 (1.1744)
Size	0.2879*** (19.5242)	-0.3172*** (-16.4911)	0.0098*** (4.2508)	-0.3331*** (-17.3140)
Age	-0.0050 (-1.5176)	0.0111*** (2.6959)	0.0028*** (5.4037)	0.0089** (2.0469)
Growth	0.1856** (2.3263)	0.1117 (1.1069)	0.1509*** (11.8415)	-0.0419 (-0.3901)
Dual	0.0259 (0.6497)	0.0631 (1.2504)	-0.0152** (-2.4251)	0.0859 (1.6448)
First	0.2166* (1.9273)	0.1343 (0.9444)	0.0637*** (3.5736)	0.1419 (0.9556)
DirNum	-0.0072 (-1.3334)	-0.0247*** (-3.6446)	-0.0016* (-1.8544)	-0.0251*** (-3.5849)
Inst	-0.0270 (-0.3240)	-0.1411 (-1.3378)	-0.1221*** (-9.1577)	-0.0918 (-0.8213)
SOE	0.1194*** (3.2148)	0.2697*** (5.7395)	0.0521*** (9.0329)	0.2373*** (4.9072)
Constant	0.8239** (2.5222)	7.8441*** (18.9749)	-0.2547*** (-4.9962)	8.0484*** (18.9318)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	6047	6047	5719	5719
R-squared	0.3007	0.1407	0.1973	0.1384

continuous adaptation of corporate structures and business models, fostering gradual digital transformation, and efficiently bridging the gap between technological advancements and effective management practices.

Heterogeneity analysis

Regional differences. According to dynamic capability theory, a firm’s dynamic capability is greatly affected by its existing capability endowment (Barreto, 2010). Due to factors such as economic accumulation, topography, history, and resource endowment, China’s eastern and central-western regions differ considerably in digital infrastructure. The eastern area has abundant digital infrastructure, talents, technological innovation, and digital financial resources, which enable firms in the eastern region to accelerate digital transformation (Liu and Dong, 2021). Compared with firms in China’s central-western region, firms in the eastern region typically have stronger dynamic capabilities of digital transformation. Therefore, we expect firms in the eastern region to have stronger technical abilities to reduce ESG decoupling than firms in the central-western area.

We divide the full sample into central-western and eastern region sub-groups based on firm location to investigate this regional heterogeneity.¹ As shown in Column (1) and Column (2) of Table 13, the coefficient of digital transformation (*Digital*) is significantly negative in the eastern region. However, although the coefficient for digital transformation remains negative in the central-western area, its absolute value is considerably smaller than that in the eastern region. Following Wang et al. (2023), we use Chow Test to identify the differences in coefficients across groups and find that there is a statistically significant difference in

coefficients between central-western and eastern region sub-groups ($p < 0.0001$), which is in line with our expectation. In the central-western regions, the governance effect of digital transformation on ESG decoupling is not as pronounced as that in the eastern regions. To address the problem of unbalanced regional development, it is crucial to have the impetus of policy initiatives. The government should increase resources and technology investment in the central-western regions to help their enterprises accelerate digital transformation.

GRI following. The CSRC and stock exchanges encourage listed companies to follow Global Reporting Initiative (GRI) guidelines when preparing ESG reports. The GRI guidelines aim to improve sustainability reports’ information quality, comparability, and credibility worldwide. The compliance of GRI guidelines makes the quality of firms’ ESG reports higher, enhances the transparency of non-financial information, and reduces information asymmetry. Previous studies find that firms following ESG-promoting institutions typically have better ESG disclosure (Ali and Frynas, 2018), strengthen ESG report credibility by following GRI guidelines, and reduce ESG decoupling (García-Sánchez et al., 2022). Therefore, ESG decoupling is less severe in firms following GRI guidelines, and the impact of digital transformation on ESG decoupling may be less noticeable. Based on the above analysis, we expect that the nexus between digital transformation and ESG decoupling is more pronounced in firms that do not follow GRI guidelines.

To test the moderating role of following the GRI, we divide the total sample into two sub-groups according to whether a firm prepares ESG reports based on GRI guidelines. Column (3) and Column (4) of Table 13 represent the regression results of the two sub-groups. A significant negative relationship between digital transformation (*Digital*) and ESG decoupling exists only in firms that do not follow GRI recommendations (-0.0900 , $T = -4.5586$), and there is a statistically significant difference in coefficients between the two sub-groups ($p < 0.0001$), which is in line with our expectations.

Economic consequences. This paper further explores whether digital transformation can influence corporate high-quality development by restraining ESG decoupling. Digital technology has brought about information dissemination across time and space, and companies can improve the efficiency of their information processing and circulation (Hansen and Sia, 2015). ESG disclosure, as an essential marketing tool, can respond to an increasingly competitive business environment more effectively (Ryou et al., 2022) and gain a sustainable competitive advantage (Flammer, 2015). Companies using ESG reports to build legitimacy can reduce information asymmetry between firms and stakeholders and mitigate conflicts with stakeholders (Harjoto and Jo, 2011). With the help of digital transformation, companies disclose more reliable, comprehensive information to stakeholders, effectively meeting the information efficiency required for capital market transactions (Wu et al., 2021). ESG information that is more aligned with actual performance is more valuable, as it helps stakeholders better judge firms’ operating situations and development prospects. As a result, firms can obtain good reputations and financial resources, thus improving productivity and promoting high-quality corporate development.

This paper uses firms’ total factor productivity (TFP) to measure their high-quality development and examines the effect of the relationship between corporate digital transformation and ESG decoupling on TFP. Specifically, we use the stepwise regression method to examine whether corporate digitalization can improve TFP by reducing ESG decoupling. TFP is calculated

Table 13 The impact of regional differences and GRI following.

Variables	(1) Eastern Region Decoupling	(2) Central-western Region Decoupling	(3) Not following GRI Decoupling	(4) Following GRI Decoupling
Digital	-0.1394*** (-6.2067)	-0.0241 (-0.6476)	-0.0900*** (-4.5586)	-0.0503 (-1.0922)
Lev	0.0256 (0.1648)	0.0365 (0.1557)	0.1681 (1.2893)	-0.7036** (-2.0887)
ROE	0.1207 (0.4835)	-0.2571 (-0.8038)	-0.2408 (-1.1903)	-0.3861 (-0.8163)
Size	-0.3129*** (-14.0934)	-0.2624*** (-7.4178)	-0.1641*** (-7.8011)	-0.1927*** (-4.7177)
Age	0.0086* (1.8345)	0.0243*** (2.8964)	0.0096** (2.2670)	-0.0277*** (-2.8717)
Growth	0.0456 (0.4338)	-0.1506 (-0.8783)	0.1073 (1.1840)	-0.0821 (-0.3481)
Dual	0.0556 (0.9710)	0.1344 (1.3091)	0.0492 (0.9664)	0.1579 (1.2673)
First	0.3135* (1.9283)	-0.3976 (-1.4852)	0.2137 (1.4858)	-0.2520 (-0.7900)
DirNum	-0.0325*** (-3.9395)	-0.0181 (-1.5658)	-0.0203*** (-2.8223)	0.0043 (0.3207)
Inst	-0.0548 (-0.4597)	-0.1223 (-0.6399)	-0.0675 (-0.6427)	-0.5927** (-2.5465)
SOE	0.2048*** (3.6672)	0.3819*** (4.2780)	0.2026*** (4.2951)	0.4427*** (3.6261)
Constant	7.5839*** (15.7613)	5.8383*** (6.1904)	4.2294*** (9.3000)	4.1937*** (4.1225)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
P value	0.0000***	0.0000***		
N	4484	1701	5053	1132
R-squared	0.1438	0.2017	0.0992	0.2453

according to Levinsohn and Petrin (2003). As reported in Column (1) of Table 14, the coefficient of digital transformation (Digital) is significantly positive at $p < 0.01$, indicating that digital transformation contributes substantially to increased TFP. Column (2) shows that the coefficient of digital transformation (Digital) decreases but remains significantly positive after including the mediator ESG decoupling, which suggests that digital transformation’s inhibiting effect on ESG decoupling can further enhance firms’ high-quality development proxied by TFP.

Discussion and conclusion

Discussion. Existing studies on ESG decoupling’s influencing factors mainly focus on the monitoring contexts (Tashman et al., 2019; Zhao et al., 2022; Yu et al., 2020; Marquis and Qian, 2014; Kim and Lyon, 2015), market pressures (Arouri et al., 2021; Zhang, 2022; García-Sánchez et al., 2021), firm characteristics (Parra-Domínguez et al., 2021; Li and Wu, 2020; Marquis et al., 2016), corporate governance (Gull et al., 2023; Eliwa et al., 2023), and individual psychology (Shahab et al., 2021; Al-Shammari et al., 2019; Sauerwald and Su, 2019; García-Sánchez et al., 2020). However, there are still several unresolved issues in the existing literature. First, there is limited literature exploring the mechanism of governing ESG decoupling from the technological perspective. Prior research on the impact of digital technology on corporate ESG decoupling is still scarce, with only fintech and digital transformation on corporate greenwashing (Xie et al., 2023; Sun et al., 2023). Second, most studies use two external ESG databases to measure ESG decoupling, and there are substantial interdependencies between these databases. As suggested by Velte (2023), solid measures of ESG decoupling should compare quantitative performance measures and qualitative descriptions

on ESG reports and need to include automated text analyses of sustainability reports for future research designs. Third, extant studies mainly regard ESG decoupling as an impression management behavior of managers, ignoring that ESG decoupling may also be subject to the limitation of managers’ information gathering and information analysis capabilities.

Regarding the above issues in the existing literature, and in response to Velte’s (2023) calling for text analysis design and strengthening ESG decoupling research, this paper uses textual analysis to measure ESG reporting’s optimistic tone, defines ESG decoupling as the gap between the optimistic tone of corporate ESG reports and actual ESG performance, and investigates the efficacy of corporate digital transformation on ESG decoupling. Our study proposes that corporate digital transformation strengthens firms’ information processing ability, alleviates information asymmetry, and reduces the gap between firms’ ESG reporting and ESG activities. Our paper explores the mechanism of governing ESG decoupling from the technological perspective, adopts an automated textual analysis method to measure ESG decoupling, and considers ESG decoupling from both the impression management perspective and the information quality view of ESG decoupling, thereby filling the gap in the existing literature.

Our study relates closely to an article examining the impact of digital transformation on a firm’s greenwashing (Sun et al., 2023). Nevertheless, our study is markedly distinguishable from Sun et al. (2023). First, we define ESG decoupling as the gap between the optimistic tone of corporate ESG reports and actual ESG performance (Sauerwald and Su, 2019; Zhang, 2022) and use metrics to measure ESG reporting’s optimistic tone through textual analysis (Tetlock et al., 2008; Arslan-Ayaydin et al., 2016).

Table 14 Digital transformation, ESG decoupling, and TFP.

Variables	(1) TFP	(2) TFP
Digital	0.0426*** (6.0854)	0.0413*** (5.8845)
Decoupling		-0.0106** (-2.2789)
Lev	0.6198*** (13.1536)	0.6221*** (13.2047)
ROE	1.7507*** (23.9894)	1.7511*** (24.0040)
Size	0.8327*** (123.5722)	0.8292*** (120.0198)
Age	0.0001 (0.0896)	0.0003 (0.1927)
Growth	-0.3667*** (-9.9800)	-0.3656*** (-9.9515)
Dual	-0.0192 (-1.0627)	-0.0183 (-1.0129)
First	0.0105 (0.2044)	0.0110 (0.2144)
DirNum	0.0023 (0.9237)	0.0020 (0.8124)
Inst	0.1215*** (3.1831)	0.1209*** (3.1689)
SOE	0.0624*** (3.6902)	0.0656*** (3.8696)
Constant	-7.6294*** (-51.3971)	-7.5462*** (-49.3821)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	5695	5695
R-squared	0.8781	0.8782

In contrast, Sun et al. (2023) consider ESG scores in the Asset4 database as ESG performance indicators and Bloomberg’s database as a source of ESG reporting measures. However, these databases have substantial interdependencies, as the Asset4 database also analyzes ESG reports, and the Bloomberg database also includes ESG performance measures (Velte, 2023). Given Velte’s (2023) criticism of existing measures of ESG decoupling, we follow his suggestion and adopt automated textual analysis of reports to gain ESG decoupling proxies. Secondly, our mechanism tests focus on analyzing how digital transformation affects ESG decoupling from the input and output perspectives of the ESG reporting process. Although Sun et al. (2023) examine the governance role of digital transformation, we explore the empowering role of digital transformation in addition to digital transformation’s governance role. Furthermore, considering that the eastern regions of China have more abundant digital resources than the central-western regions, we offer additional insights into the cross-regional heterogeneity of digital transformation effects. Our study is further distinguished from Sun et al. (2023) as we exclude the impact of corporate strategic disclosure on digital transformation and conduct economic consequences tests. Overall, our study complements the work of Sun et al. (2023).

Conclusion. Based on a sample of A-share listed companies on the Shenzhen and Shanghai Stock Exchanges during 2010–2019, this paper examines the influence of corporate digital transformation on ESG decoupling and finds that corporate digital transformation can reduce ESG decoupling significantly. This relationship still holds after a series of robustness tests. Mechanism tests find that corporate digital transformation helps improve internal control and reduce information asymmetry,

thus mitigating ESG decoupling. In addition, heterogeneity examinations verify that digital transformation’s inhibitory effect on ESG decoupling mainly exists among firms in the eastern region of China and those that do not follow GRI guidance. Finally, the economic consequences study finds that digital transformation promotes high-quality corporate development by reducing ESG decoupling.

Drawing on the findings above, we put forth the following policy implications. First, the government should encourage and support corporate digital transformation across various industries, prospectively formulate differentiated digital transformation support policies, and provide policy support to drive deep integration of digital technology and the real economy. In addition, the central government should attach importance to the digital development of the central and western regions and narrow the gap between the digitalization of firms in the central and western regions and the eastern regions.

Second, regulators need to improve the institution and policy of ESG governance in the emerging digital economy environment to ensure its feasibility and operability. In response to new social responsibility problems such as severe forgery and privacy leakage arising from the digital economy, government departments should introduce laws and regulations in a forward-looking, timely manner. For example, regulators can use digital technology to establish an intelligent information disclosure system, effectively supervise enterprises to fulfill lawful and compliant information disclosure, and strengthen supervision and punishment of ESG decoupling. It is also necessary to promote public complaint and monitoring mechanisms, guarantee the effectiveness of social monitoring, and increase the public’s willingness to participate in monitoring firms’ ESG decoupling behavior.

Third, managers should seize the enormous opportunities created by the digital economy, continuously adjust the corporate organizational structure and business models, promote digital transformation incrementally, and more effectively reduce the mismatch between digital technology and business management. Meanwhile, firms should attach great importance to the social value of digital empowerment. For example, firms may expedite the development of ESG governance systems in the digital context, construct information disclosure and internal governance platforms through digital technologies, improve internal control quality, curb management’s opportunistic motives, accurately and reliably disclose ESG information, and achieve mutual benefit for firms and stakeholders.

Our study has its limitations that may be addressed in future research. First, although the use of digital keywords for text mining to depict digital transformation is a specific and feasible dimension, the use of machine learning technology to ensure the comprehensiveness, accuracy, and objectivity of keywords, and at the same time to test the robustness of the possible problems of over- or under-disclosure of digital-related information. However, the company’s digital transformation involves changes in technology, talent, organization, and strategy, etc. Further studies may measure the digital operation level more effectively using a firm-specific word dictionary to find a more interesting conclusion. Second, we define ESG decoupling as the inconsistencies between the optimistic tone of corporate ESG reports and actual ESG performance, and rely on the emotional dictionary published by Loughran and McDonald (2016) to analyze the optimistic tone. Although Loughran and McDonald’s (2016) dictionary is widely used in textual analysis studies, it does not cover all the positive Chinese words. Thus, there is a lack of authoritative Chinese sentiment dictionaries in the study of Chinese text analysis. In this regard, further research may construct a more comprehensive and accurate Chinese emotional dictionary to measure the optimistic tone of ESG reporting, and examine the economic consequence of

ESG decoupling to respond to Velte's (2023) call for more research on the consequences of ESG decoupling. Lastly, due to the widespread phenomenon of ESG decoupling in various settings (Delmas and Burbano, 2011; Tashman et al., 2019; Eliwa et al., 2023), our findings about the empowering role and governance role of corporate digital transformation on ESG decoupling can be generalized with caution to other contexts. Nevertheless, given the institutional background heterogeneities between China and other countries, we call for future research to employ the international context to investigate whether corporate digital transformation has similar or different impacts on ESG decoupling.

Data availability

The data used in this paper were obtained from the CSMAR Database and CNRDS Database. The website is available at <https://www.gtarsc.com/> and <https://www.cnrds.com/Home/Login>, respectively. However, access to these data is subject to restrictions and requires a license. Interested parties can obtain the data with the permission of CSMAR and the CNRDS Database.

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Note

1 The central-western region includes Chongqing, Inner Mongolia, Ningxia, Henan, Hubei, Hunan, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Shanxi, Xinjiang; the rest provinces belong to the eastern region.

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Author contributions

XC: conceptualization, methodology, validation, writing-original draft preparation. PW: methodology, funding acquisition, data curation, formal analysis, writing-original draft preparation, writing-reviewing and editing. ZM: data curation, software, visualization, writing-original draft preparation. YY: software, visualization, writing-reviewing and editing.

Competing interests

The author(s) declare no competing interests.

Ethical approval

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Additional information

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