# 2 When AI Powers Sustainability: Divergent Paths for Enterprise ESG Performance in China

**Ming ZENG** [1]

**Weike ZHANG** [2]

## Abstract

*The rapid advancement of artificial intelligence (AI) has the potential to enhance enterprises' Environmental, Social, and Governance (ESG) performance by improving their capability and motivation to engage in ESG initiatives. Nevertheless, the relationship between AI and enterprise ESG performance has not been extensively examined in the academic literature. Hence, this study explores the effect of AI on enterprises ESG performance, in China, utilizing a dataset comprising Chinese 1,270 publicly listed enterprises across 187 cities from 2006 to 2019. The findings indicate that AI enhances enterprise ESG performance, a conclusion supported by various robustness tests. However, the influence of AI on enterprise ESG performance exhibits heterogeneity. Additionally, the underlying mechanisms suggest that AI contributes to improved enterprise ESG performance by increasing analyst attention and facilitating digital transformation. Furthermore, marketization level and business environment can amplify the effectiveness of AI in enhancing enterprise ESG performance. These findings can offer valuable insights for the advancement of AI and the enhancement of enterprise ESG performance.*

**Keywords**: *Artificial intelligence (AI); Enterprise ESG performance; Analyst attention; Digital transformation; Marketization level; Business environment*.

**JEL classification:** *D22, O33, Q56*

## 1. Introduction

The increasing challenges associated with global environmental degradation (Su et al., 2022), a lack of social responsibility, and persistent governance scandals (Su et al., 2023a) have rendered the conventional enterprise evaluation framework—primarily focused on financial performance—insufficient for meeting the requirements of sustainable development (Zhu et al., 2023). In this regard, the Environmental, Social, and Governance (ESG) framework, initially introduced by the United Nations Global Compact in 2004, has rapidly gained prominence as a critical paradigm for the strategic transformation of enterprises globally (Vezeteu et al., 2024). Over the years, the

[1] *School of Economics, Xihua University, No. 999, Tuqiao Jinzhou Road, Jinniu District, Chengdu, China, 610039. Email: zengming@mail.xhu.edu.cn.*

[2] *Corresponding Author, School of Public Administration, Sichuan University, No. 24, South Section 1, First Ring Road, Wuhou District, Chengdu, China, 610064. Email: zhangwk@scu.edu.cn.*

implementation of ESG practices within enterprises has become integral to sustainable development (Wan et al., 2023). According to the Global Sustainable Investment Alliance (GSIA)[3], the global allocation for ESG investments reaches $5.588 trillion in 2022, representing over one-sixth of the total sustainable investment market. Enhancing the preparedness and commitment of enterprises to adopt ESG practices—termed enterprise ESG performance—is essential for advancing ESG initiatives and promoting sustainable development (Guo et al., 2024a). However, the implementation of ESG practices often incurs significant costs and generates positive externalities, which can substantially hinder enterprise ESG performance (Gao and Liu, 2023). According to the Institute of Management Accountants (IMA)[4], merely 33% of Chinese sample enterprises were involved in ESG practices in the year 2022. Hence, improving enterprise ESG performance has become prominent topics in contemporary academic discussions (Gao et al., 2024).

Artificial intelligence (AI) can greatly affect enterprises (Zhang and Zeng, 2024). It has the potential to improve operational efficiency and increase profitability, thereby providing a solid material basis for enterprises to engage in ESG practices (Chen et al., 2024; Yu, 2024). Additionally, AI can enhance the visibility and influence of enterprises, amplify the anticipated advantages associated with ESG initiatives, and address the positive externalities inherent in ESG, thus motivating enterprises to adopt these practices (Chen and Zhang, 2024). It is clear that AI offers a promising avenue for improving enterprise ESG performance. However, their relationship remains inadequately examined (Huang et al., 2024). There is a lack of comprehensive analysis regarding how AI improves enterprise ESG performance, and empirical evidence to support such claims is limited.

The relevant literature for this study includes: the AI's impact and the determinants influencing enterprise ESG performance. The former emphasizes its economic ramifications (Qin et al., 2024a, 2024b, 2024c; Zhou et al., 2024), such as fostering economic growth (Deng et al., 2023), driving innovation (Babina et al., 2024), and increasing resource efficiency (Zhang and Zeng, 2024). However, limited research explores its non-economic implications, particularly its influence on ESG performance. While substantial scholarship exists regarding AI's contributions to environmental protection (the E item) (Zhang et al., 2025), few studies have explored social responsibility (the S item) and enterprise governance (the G item) (Chen et al., 2024).

Conversely, the literature concerning enterprise ESG performance tends to concentrate on enterprise-specific attributes, including technical emphasis (Fang et al., 2023), management competence (Fan et al., 2024), and enterprise culture (Bai et al., 2025). Nonetheless, limited research directly examines AI-enterprise ESG performance nexus. Notably, Chen et al. (2024) employ text analysis techniques to assess the extent of AI utilization within enterprises, demonstrating that a broader application of AI correlates with enhanced ESG performance. Similarly, Li et al. (2024a) investigate the AI adoption-ESG performance nexus, concluding a positive association. Furthermore, Lin and Zhu (2025) and Huang et al. (2024), utilizing China's AI pilot policy, illustrate that AI can improve enterprise ESG performance.

While these studies have contributed to understanding the AI-enterprise ESG performance nexus, they fail to delve into the theoretical foundations of this nexus at the city level. Undertaking research at the city level can significantly improve the validity of econometric regression outcomes. Furthermore, it facilitates a more comprehensive investigation of associated subjects, such as the examination of the heterogeneity among various types of cities. Additionally, they do not address the intermediary effects of analyst attention and digital transformation, nor do they consider the regulatory effects of marketization level and business environment. In light of this context, this study is conducted. The analysis is based on a dataset that includes 1,270 publicly

[3] *GSIA: https://www.gsi-alliance.org/members-resources/gsir2022/.*

[4] *IMA: https://www.imachina.org.cn/Uploads/File/2023/08/02/u64c9cd95905eb.pdf.*

listed companies in China, spanning 187 cities from 2006 to 2019. Initially, we employ a city-year fixed effects model to establish that AI positively influences enterprise ESG performance. And it remains valid through various robustness tests, including alterations to the dependent and independent variables as well as different regression methodologies. Subsequently, we carry out the heterogeneity analysis through the lenses of ESG items, city classifications, industry categories, and types of enterprises. Finally, we investigate the underlying mechanisms through which AI affects ESG performance, specifically examining whether AI enhances enterprise ESG performance via increased analyst attention and digital transformation, and whether marketization level and business environment amplify AI's effectiveness in improving enterprise ESG performance.

The contributions are as follow: Firstly, this study integrates AI-enterprise ESG performance nexus, examining the factors that drive enterprise ESG practices from an AI perspective. The findings carry significant practical meanings for advancing ESG practices within enterprises. While prior studies have emphasized the importance of ESG practices for both enterprise and society (Chen and Xie, 2022; Qian, 2024), there is a notable scarcity of literature addressing its influencing factors, particularly regarding the direct influence of AI on enterprise ESG performance (Chen et al., 2024). Besides, we examined the AI-enterprise ESG performance at the city level, which has enhanced the robustness and depth of the findings.

Secondly, this study primarily highlights the non-economic advantages of AI within the context of micro enterprises, thereby prompting a broader investigation into AI's impact on their behaviors. While the existing body of literature has largely concentrated on the economic benefits of AI—such as increased production capacity, optimized production processes, and enhanced market competitiveness (Babina et al., 2024)—there is a notable scarcity of research addressing the significant influence of AI on non-economic behaviors within enterprises (Lee et al., 2025). This study aims to expand the academic discourse by exploring the effects of AI on non-economic activities within enterprises.

Thirdly, the study elucidates the underlying mechanisms. Specifically, it posits that AI can enhance ESG performance by increasing analyst attention and facilitating digital transformation. Additionally, it suggests that marketization level and business environment may further amplify the positive effects of AI on enterprises' ESG performance. Consequently, this study contributes to a deeper understanding of the relationship between AI and enterprise ESG performance.

The subsequent section is as follows. Section 2 is the theoretical analysis and hypotheses. Section 3 shows the research design. Section 4 reports the results and discussions. Section 5 explores the underlying mechanism of AI affecting enterprise ESG performance. And the conclusions and implications are concluded in Section 6.

# 2. Theoretical Analysis and Hypothesis Development

## *2.1. Impact of AI on Enterprise ESG Performance*

The current literature suggests that how AI affects enterprise ESG performance can be analyzed through capability and motivation. From the capability perspective, AI significantly bolsters enterprises' ability to protect the environment (Zhang and Zeng, 2024). It promotes innovative activities and technological advancements, thereby enabling enterprises to adopt cutting-edge green production technologies and efficient manufacturing processes (Li et al., 2023). Consequently, this helps the carbon and pollutant emission reduction (Zhang et al., 2023a). Additionally, AI plays a crucial role in optimizing resource utilization and minimizing waste (Song et al., 2024). For example, it aids enterprises in selecting low-carbon, high-quality supply chains

(Qin et al., 2024b) and enhances real-time energy monitoring and optimization of energy usage strategies.

Furthermore, AI improves production processes by leveraging modern digital technologies, which increases labor efficiency and overall production capacity (Chen et al., 2024). This enhancement is advantageous for boosting business revenue, thereby creating a foundation for enterprises to meet their social responsibilities (Chen et al., 2024). Lastly, AI assists enterprises in identifying, analyzing, and managing various operational risks through the application of advanced models developed using deep learning techniques (Lee et al., 2024; Yang and Wu, 2022). This utilization of AI reduces uncertainty in enterprise management, enhances the effectiveness of risk control measures, and ultimately contributes to improved governance outcomes for enterprises.

From a motivational perspective, AI enhances the transparency of enterprise environmental protection information, thereby reducing market information asymmetry and increasing enterprise engagement in environmental initiatives (Wang et al., 2025). By strengthening societal oversight of enterprise environmental practices, AI promotes the internalization of external costs associated with environmental pollution, thereby compelling enterprises to reduce emissions and invest more in environmental governance (Huo and Wang, 2023). Additionally, AI amplifies the societal impact of enterprise participation in environmental protection, assisting companies in cultivating a responsible enterprise image and securing financing opportunities, which further incentivizes them to engage in additional environmental protection activities (Chen and Zhang, 2024).

Furthermore, AI can aid enterprises in developing a comprehensive language model that assesses the emotional sentiments expressed on social media by both employees and consumers (Wang et al., 2022). This capability enhances communication between enterprises and their stakeholders, facilitating a deeper understanding of stakeholder expectations. Concurrently, AI encourages enterprises to adapt their policies promptly in response to these expectations, thereby effectively fulfilling their social responsibilities. Lastly, AI can support directors and senior management in fostering an awareness of enterprise governance, enhancing their understanding of governance principles, and guiding the establishment of a modern enterprise management framework (Johnson, 2019), which includes the reinforcement of internal controls, the development of a fair compensation structure, and the equitable distribution of authority within the organization.

Therefore, this study proposes hypothesis H1:

**H1: AI can significantly facilitate enterprise ESG performance.**

## *2.2. Underlying Mechanism of AI Affects Enterprise ESG Performance*

### 2.2.1 The Intermediary Effects of AI on Enterprise ESG Performance

This study investigates intermediary effects of AI on enterprise ESG performance from the perspectives of both pressure and power. From the pressure standpoint, AI may influence enterprise ESG performance by shaping analyst attention. Additionally, from the power standpoint, AI can affect enterprise ESG performance by facilitating digital transformation.

Analyst attention refers to the mechanism by which analysts convey the operational status of enterprises to the capital market through the examination of both publicly accessible and confidential information. This attention is pivotal in improving enterprise ESG performance (Wang and Cao, 2023). Firstly, analyst attention bridges the gap between enterprises, investors, and consumers, thereby alleviating information asymmetry (Huang et al., 2025). Increased transparency in the dissemination of information exerts external pressure on enterprises to prioritize ESG initiatives, as both investors and consumers are progressively emphasizing the importance of sustainability practices and are more likely to engage with enterprises that exhibit

social and environmental responsibility. Secondly, analyst attention facilitates the public disclosure of enterprises' information and practices, which can motivate enterprises to invest in ESG initiatives (Li et al., 2024b). In an effort to cultivate a responsible enterprise image and enhance their competitive position in the market, enterprises are increasingly engaging in ESG-related activities.

AI has the potential to augment analyst attention towards enterprises, thereby enhancing their ESG performance (Imjai et al., 2025). Firstly, modern digital technological infrastructures, such as 5G networks and cloud computing—integral components of AI—provide a robust framework for analysts to collect and analyze extensive, real-time data related to enterprises. Secondly, AI equips analysts with sophisticated analytical tools that facilitate a scientific and precise assessment of business operations. Finally, AI streamlines the report-writing process for analysts by automating the generation of financial evaluation reports and comprehensive analytical recommendations, thereby improving their overall productivity.

Therefore, this study proposes hypothesis H2a:

**H2a: AI can facilitate enterprise ESG performance by enhancing analyst attention.**

Digital transformation encompasses the comprehensive integration of digital technologies, leading to fundamental changes in production processes, management systems, and business models (Cai et al., 2023). The introduction of advanced and efficient digital technologies is crucial for optimizing production chains, enhancing resource efficiency, and reducing pollution emissions (Su et al., 2023; Zhang et al., 2024). Additionally, digital transformation promotes a more streamlined, transparent, and hierarchical management structure within enterprises, effectively aligning various stakeholders' interests. This alignment strengthens the implementation of enterprise social responsibility initiatives and raises the standards of internal governance (Cai et al., 2023).

The relationship between AI and enterprise digital transformation is characterized by technological isomorphism, which serves as a foundational technical basis for organizations pursuing digital transformation initiatives (Holmstrom, 2022). AI not only accelerates the adoption and advancement of digital technologies within enterprises but also aids in the integration and analysis of heterogeneous data from various sources, thereby contributing to the accumulation of data assets. Moreover, AI enables enterprises to automate production processes, replacing repetitive labor, modernizing production workflows and business models, and advancing the overall digital transformation of enterprises (Taherizadeh and Beaudry, 2023).

Therefore, this study proposes hypothesis H2b:

**H2b: AI can facilitate enterprise ESG performance by stimulating digital transformation.**

### 2.2.2 The Regulatory Effects of AI on Enterprise ESG Performance

Marketization level is conceptualized as the degree to which a market economy forms the foundational economic structure of a region, serving as a metric for economic maturity and the marketization process (Wang et al., 2021). A higher level of marketization is correlated with a more liberal movement of production factors, a more robust framework for the protection of property rights, and increased market competition. Theoretically, marketization level enhances the impact of AI on enterprise ESG performance.

Firstly, regions with higher levels of marketization are more proficient in attracting and retaining digital talent, technology, data, and other essential resources, which in turn fosters improvements in AI capabilities and supports enterprise ESG initiatives (Fu et al., 2025). Secondly, a significant degree of marketization reflects diminished governmental intervention and heightened market competition, which compels enterprise leaders to embrace sustainable ESG principles and utilize

AI technologies to bolster their ESG efforts (An et al., 2023). Finally, in regions characterized by advanced marketization, the regulatory frameworks governing market practices, including ESG information disclosure, are typically more comprehensive and standardized, thereby incentivizing enterprises to prioritize their ESG practices (You et al., 2025).

Therefore, this study proposes hypothesis H3a:

**H3a: Marketization level can enhance the positive impact of AI on enterprise ESG performance.**

Business environment refers to the institutional frameworks that enterprises encounter in their operational activities, encompassing elements such as governmental efficiency, the legal system, the financial landscape, and the degree of international integration (Luo et al., 2023). From a theoretical perspective, a conducive business environment enhances the capacity of AI to improve enterprise ESG performance.

Firstly, a favorable business environment enables enterprises to take advantage of efficient administrative processes and substantial tax incentives (Zhang et al., 2023b), which in turn lowers operational costs and creates a conducive foundation for AI to effectively enhance ESG performance. Secondly, a strong innovation protection system, which is a hallmark of a favorable business environment, motivates enterprises to increase their adoption of AI technologies and their willingness to invest in ESG initiatives (Luo et al., 2023). Furthermore, a supportive business environment enhances access to financing, thereby providing critical financial resources necessary for enterprises to execute ESG activities (Guo et al., 2024b). Finally, a favorable business environment is associated with a greater alignment between domestic institutional regulations in China and international standards. This alignment has facilitated the development of systematic and standardized guidelines for enterprise ESG information disclosure on a global scale, which can further encourage Chinese enterprises to engage in ESG practices.

Therefore, this study proposes hypothesis H3b:

**H3b: Business environment can enhance the positive impact of AI on enterprise ESG performance.**

# 3. Research Design

## *3.1. Data*

The AI-related data is from the International Federation of Robotics (IFR)[5]. It offers data regarding the annual installation of new industrial robots, as well as the number of operational industrial robots across diverse industries in China. This information can be further disaggregated to the city level, thereby serving as an indicator of the AI capabilities present in Chinese cities. Given that IFR currently provides data only up to the year 2019, the sample period ends in 2019. The ESG-related data is from the Bloomberg[6]. And the other data is from the China Stock Market & Accounting Research Database (CSMAR)[7]. Following the removal of samples containing missing values and outliers, the study successfully compiled a dataset comprising 1,270 enterprises across 187 cities, resulting in a total of 11,737 observations spanning from 2006 to 2019.

[5] *IFR: https://ifr.org/.*

[6] *Bloomberg: https://www.bloomberg.com/.*

[7] *CSMAR: https://data.csmar.com/.*

## 3.2. Variable

### 3.2.1 Enterprise ESG Performance

Major agencies evaluated Chinese enterprises' ESG performance, including Bloomberg, Sino-Securities Index, SynTao Green Finance, Wind, and others. Notably, Bloomberg has emerged as a leader in the field of ESG rating, having developed a comprehensive and systematic index that encompasses 46 indicators related to environmental dimensions, 46 indicators pertaining to social dimensions, and 30 indicators associated with governance dimensions (Chen and Xie, 2022). Consequently, Bloomberg's ESG data is extensively utilized within academic research, owing to its substantial sample size and rigorous evaluation framework, such as Khurram et al. (2024), Liu et al. (2024), and Nollet et al. (2016). Hence, we introduce the Bloomberg ESG score as a metric to assess Chinese enterprises' ESG performance. Simultaneously, we employ the Sino-Securities Index as an alternative proxy variable to assess Chinese enterprises' ESG performance, thereby conducting robustness checks to strengthen the validity of the research findings.

### 3.2.2 AI

AI encompasses a wide array of concepts, which complicates the systematic assessment of AI levels across Chinese cities. In this regard, current research frequently employs industrial robot data to measure AI levels (Zeng and Zhang, 2024). An industrial robot is defined as an automated intelligent tool designed to replicate human actions within the industrial production process. These robots exhibit key characteristics associated with AI, namely intelligence, autonomy, and adaptability, thereby positioning them as a central focus in the advancement of AI technologies (Acemoglu and Restrepo, 2020). Following Zeng and Zhang (2024), this study measures AI by the ratio of urban industrial robots to their employment levels. The specific formula is shown in Formula (1):

$$AI = \sum_{k=1}^{K} \frac{empl_{i,k,t=2005}}{empl_{i,t=2005}} \times \frac{robot_{kt}}{empl_{k,t=2005}} \quad (1)$$

where *i*, *k*, and *t* represent city, industry, and year, respectively; robot denotes number of industrial robots, and empl indicates employment.

This calculation methodology fundamentally incorporates the primary concept of Bartik instrumental variable method, thereby serving as an effective indicator of urban AI level. Besides, this study measures AI based on newly installed robots (AI_install) and existing robot stock (AI_stock).

### 3.2.3 Control Variables

This study introduces control variables, as Table 1 presents. Table 1 provides these variables' descriptive statistics. As shown, the average value of ESG is 25.237. It agrees with the value 20.35 reported by Chen and Xie (2022) who also employ Bloomberg ESG data to assess the ESG performance of Chinese enterprises. Consequently, it can be inferred that the data utilized in this research, following a thorough cleaning process, is dependable.

**Table 1. Descriptive statistics**

| Variables | N | Mean | S.D. | Min | Max |
|---|---|---|---|---|---|
| **Dependent variable** | | | | | |
| ESG | 11737 | 25.237 | 8.692 | 6.198 | 65.778 |
| **Independent variable** | | | | | |
| AI_install (units/hundred workers) | 11737 | 0.069 | 0.060 | 0.002 | 0.285 |
| AI_stock (units/hundred workers) | 11737 | 0.281 | 0.270 | 0.007 | 1.424 |

| | | | | | |
|---|---|---|---|---|---|
| **Controls** | | | | | |
| The enterprises' annual net profit (billion RMB) | 11737 | 2.366 | 13.744 | -17.049 | 313.361 |
| State-owned enterprise or not (yes=1; no=0) | 11737 | 0.553 | 0.497 | 0 | 1 |
| The ratio of liabilities to assets | 11737 | 0.503 | 0.255 | 0.008 | 13.629 |
| The shares of the top five shareholders (0,1) | 11737 | 0.546 | 0.209 | 0.200 | 0.991 |
| Tobin's Q value | 11737 | 2.560 | 2.329 | 0.205 | 45.651 |
| The number of directors with overseas experience (unit) | 11737 | 0.558 | 1.015 | 0 | 9 |
| The number of independent directors (unit) | 11737 | 3.427 | 0.796 | 0 | 8 |

### *3.3. Method*

This study establishes the following model to explore how AI affects Chinese enterprise' ESG performance.

$$ESG_{jt} = \alpha_0 + \beta AI_{jit} + \eta C_{j+u_j+v_t+\varepsilon_{jt}} \quad (2)$$

where *j*, *i*, and *t* represent enterprise, city, and year, respectively; ***ESG*** is enterprise ESG performance; ***AI*** is urban AI level, and $\beta$ captures how AI affects ESG; C represents these control variables; $u_j$ and $v_t$ are the enterprise and year fixed-effects (FE) respectively; $\alpha_0$ is the intercepted item, and $\varepsilon_{jt}$ is a random error vector.

## 4. Results and Discussions

### *4.1. Baseline Regression Results*

Table 2 provides the results of Model (2). All columns exhibited statistically significant positive regression coefficients. The findings indicate that the implementation of AI enhances enterprise ESG performance. In particular, the coefficient associated with AI_install in Column (2) is 7.855. This indicates that a one standard deviation increase in the number of newly installed industrial robots per hundred workers within Chinese cities is associated with a 0.054 (7.855□0.060/8.692) standard deviation increase in the ESG performance score of local enterprises. Similarly, 1.792 for AI_stock in Column (4) means that each extra standard deviation in the number of urban industrial robots per hundred workers enhances enterprises' ESG performance by 0.056 (1.792□0.270/8.692) standard deviations. In conclusion, the benchmark regression analysis substantiates the assertion that AI positively influences enterprise ESG performance, thereby corroborating Hypothesis H1.

The conclusions drawn in this study are fundamentally aligned with existing literature in the field. Chen et al. (2024) utilized text analysis to assess the extent of AI implementation within enterprises, establishing that a higher level of AI integration correlates with improved ESG performance. Furthermore, Chen and Zhang (2025) conducted a multivariate regression analysis, demonstrating that AI applications within enterprises facilitate enhanced ESG performance. Similarly, Li et al. (2024) identified their significant positive relationship. Additionally, Huang et al. (2024) and Lin and Zhu (2025) applied the DID methodology to evidence that the AI-policies improve enterpries ESG performance. While the perspectives of these studies differ from those presented in this study, their findings are congruent with the conclusions of this study. This alignment among various studies serves to reinforce the validity of the findings presented herein.

**Table 2. Baseline regression results**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| AI_install | 8.407*** | 7.855*** | | |
| | (2.586) | (2.582) | | |
| AI_stock | | | 1.871*** | 1.792*** |
| | | | (0.564) | (0.567) |
| Controls | No | Yes | No | Yes |
| Enterprise fixed-effect | Yes | Yes | Yes | Yes |
| Year fixed-effect | Yes | Yes | Yes | Yes |
| N | 11,737 | 11,737 | 11,737 | 11,737 |
| $R^2$ | 0.842 | 0.843 | 0.842 | 0.843 |

Note: *** p < 0.01. Robust standard errors are in parentheses.

## *4.2. Robustness Tests*

### 4.2.1 Alternative Measure for Enterprise ESG Performance

In numerous organizations focused on enterprise ESG assessments, the Sino-Securities Index plays a significant role and has gained considerable traction within academic discourse (Kuai et al., 2025). This index is developed by Chinese ESG evaluation organizations with the help of the algorithm-based big data method. Following Kuai et al. (2025), this study re-evaluates enterprise ESG performance by utilizing the Sino-Securities Index. The results in Table 3 indicate that the positive coefficients for AI_install and AI_stock further substantiate the baseline assertion.

### 4.2.2 Alternative Measure for AI

Drawing inspiration from Zeng and Zhang (2024)'s methodology, this study employs the AI enterprise density to re-evaluate Chinese urban AI level, quantified by the number of AI enterprises per thousand residents. Enterprises that incorporate AI-related terminology in their name or business activities are classified as AI enterprises. And the data regarding the number of AI enterprises within the cities is sourced from statistics provided by the "Tianyan Check" website. Column (3) of Table 3 reveals a significant positive sign, which aligns with the above.

### 4.2.3 Instrumental Variable Method

The outcomes of regression analyses can be subject to bias if important variables are excluded from the model. To address this issue, we utilize the instrumental variable approach to reduce regression bias. In accordance with Zhang and Zeng (2024), this method utilizes data on industrial robots across various sectors in the United States as a proxy for data pertaining to Chinese industries, thereby enabling the creation of instrumental variables. Consequently, this study establishes AI_install_IV and AI_stock_IV as the instrumental variables for AI_install and AI_stock, respectively.

As a prominent entity in the field of AI, the United States has had a substantial impact on Chinese AI level. Nevertheless, the AI capabilities of the United States cannot directly affect Chinese enterprise ESG performance. Therefore, the use of these IVs is theoretically warranted. Additionally, this study includes an unidentifiable test and a weak instrumental variable test, the outcomes of which substantiate the statistical validity of the instrumental variables formulated in this paper. As illustrated in Table 3, the findings indicate a beneficial influence of AI on enterprise ESG performance. Consequently, the findings derived from the instrumental variable method substantiate the reliability of the above baseline conclusions.

**Table 3. Robust test results**

| | Alternative measure for ESG | | Alternative measure for AI | IV method | | | |
|---|---|---|---|---|---|---|---|
| | | | | IV for AI_install | | IV for AI_stock | |
| | The Sino-Securities Index | The Sino-Securities Index | ESG | Stage1: AI_install | Stage 2: ESG | Stage1: AI_stock | Stage2: ESG |
| | (1) | (2) | (3) | （4） | (5) | （6） | (7) |
| AI_install | 1.064** | | | | 8.303*** | | |
| | (0.495) | | | | (2.963) | | |
| AI_stock | | 0.250** | | | | | 1.878*** |
| | | (0.109) | | | | | (0.630) |
| The AI enterprise density | | | 0.462** | | | | |
| | | | (0.199) | | | | |
| AI_install_IV | | | | 0.219*** | | | |
| | | | | (0.003) | | | |
| AI_stock_IV | | | | | | 1.186*** | |
| | | | | | | (0.013) | |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Enterprise fixed-effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed-effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 10,518 | 10,518 | 11,737 | 11,737 | 11,737 | 11,737 | 11,737 |
| $R^2$ | 0.619 | 0.619 | 0.843 | | 0.717 | | 0.717 |
| Kleibergen-Paap rk LM statistic | | | | 1265.19*** | | 1195.74*** | |
| Cragg-Donald Wald F statistic | | | | 32373.38*** | | 35440.75*** | |
| Kleibergen-Paap Wald rk F statistic | | | | 6127.74*** | | 8467.29*** | |

Note: *** p < 0.01; ** p < 0.05. Robust standard errors are in parentheses.

## *4.3. Heterogeneity Analysis*

### 4.3.1 ESG Item Heterogeneity

Enterprise ESG performance encompasses three distinct items: E, S, and G. The effects of AI on each item are presented in Table 4. The regression coefficients for E are statistically significant. This suggests that AI positively impacts enterprises' environmental responsibility. Concurrently, the regression results for S reveal that both AI_install and AI_stock exhibit significance, evidencing that AI can enhance their social responsibility performance.

In the case of G, the coefficients for AI_install and AI_stock do not meet the threshold for significance at the 10% level. Hence, AI has minimal influence on the governance levels of enterprises. One possible explanation for this finding is that G item is inherently more challenging to modify compared to E item and S item. Governance requires a systematic and holistic approach, which necessitates institutionalized modifications within enterprises. Additionally, governance metrics are frequently more challenging to quantify and substantiate compared to environmental and social indicators (Tristan, 2024). As a result, AI may not sufficiently incentivize enterprises to improve their governance practices through heightened oversight.

### 4.3.2 Region Heterogeneity

To test regional disparities, the samples are categorized into western cities, and eastern and central cities, and separate models are performed for them. Table 4 indicates that AI can improve

the ESG performance of enterprises located in eastern and central cities; however, it does not hold true for western cities. Indeed, Chinese western cities exhibit a degree of underdevelopment, particularly concerning the understanding and implementation of ESG principles. This is especially evident in the E and S items, where there is a notable deficiency in effective external oversight mechanisms and a well-established institutional framework.

#### 4.3.3 Resource Heterogeneity

Resource-based cities have established a development trajectory characterized by high input and low efficiency, primarily due to their abundant resource endowments, which has resulted in significant environmental degradation over an extended period (Zeng and Zhang, 2024). Hence, enterprises of resource-based cities possess the late mover advantage, enabling them to leverage AI to improve ESG performance more significantly. Hence, the sample is categorized according to the National Sustainable Development Plan for Resource-dependent Cities[8], followed by the implementation of regression analysis for each category independently. Their results are presented in Column (6) and (7) of Table 4.

**Table 4. Results of heterogeneity analysis**

| | ESG item heterogeneity | | | Region heterogeneity | | Resource heterogeneity | | Tech heterogeneity | | Ownership heterogeneity | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | S | G | Western cities | Eastern and central cities | Resource-based cities | Non-resource-based cities | High-tech industries | Non-high-tech industries | SOEs | Non-SOEs |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| **Part A: The independent variable is AI_install.** | | | | | | | | | | | |
| AI_install | 8.129* | 8.828*** | 4.779 | 8.903 | 8.352*** | 43.975*** | 4.963* | 20.154*** | -0.568 | 11.172*** | 5.535 |
| | (4.624) | (2.776) | (4.377) | (8.336) | (2.889) | (6.650) | (2.883) | (4.674) | (3.122) | (3.550) | (3.989) |
| $R^2$ | 0.655 | 0.754 | 0.809 | 0.836 | 0.844 | 0.839 | 0.844 | 0.848 | 0.848 | 0.851 | 0.842 |
| **Part B: The independent variable is AI_stock.** | | | | | | | | | | | |
| AI_stock | 2.243** | 2.030*** | 0.863 | 1.890 | 1.952*** | 9.647*** | 1.205* | 4.423*** | 0.006 | 2.434*** | 1.476* |
| | (1.075) | (0.619) | (0.865) | (2.040) | (0.630) | (1.616) | (0.626) | (0.995) | (0.697) | (0.796) | (0.868) |
| $R^2$ | 0.655 | 0.754 | 0.809 | 0.836 | 0.844 | 0.840 | 0.844 | 0.848 | 0.848 | 0.851 | 0.842 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Enterprise FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 11,521 | 11,611 | 11,737 | 1,763 | 9,971 | 1,380 | 10,353 | 4,267 | 7,449 | 6,474 | 5,224 |

Note: *** p < 0.01; ** p < 0.05; * p < 0.1. Robust standard errors are in parentheses.

The findings are statistically significant for both resource-based and non-resource-based cities. This implies that AI enhances enterprise ESG performance in both types of cities. Notably, the coefficient for the former is substantially greater than that for the latter. Specifically, for the variable AI_install, the coefficient for resource-based cities is 43.975 (standard error: 6.650), whereas for non-resource-based cities, the coefficient is 4.963 (standard error: 2.883). Similarly, for the variable AI_stock, the former has a coefficient of 9.647 (standard error: 1.616), while the latter has a coefficient of 1.205 (standard error: 0.626). Hence, AI can improve enterprise ESG performance in resource-based cities to a greater extent.

[8] *This document was released by the State Council of the People's Republic of China. Its URL is https://www.gov.cn/zwgk/2013-12/03/content_2540070.htm.*

#### 4.3.4 Tech Heterogeneity

The high-tech industries exhibit a greater demand for technical components, suggesting that enhanced compatibility with AI technology may amplify AI's ESG performance enhancement effect. Hence, it investigates the tech heterogeneity. The regression coefficients for high-tech industries in Table 4 are significantly positive, whereas those for non-high-tech industries lack statistical significance. This indicates that AI can enhance enterprise ESG performance within high-tech industries, but does not yield a similar result in non-high-tech industries.

#### 4.3.5 Ownership Heterogeneity

In contrast to non-state-owned enterprises (non-SOEs), state-owned enterprises (SOEs) in China bear a greater burden of environmental and social responsibilities. Consequently, SOEs may exhibit superior ESG performance, which highlights the possibility for AI to have a substantial impact on further advancing these enterprises' ESG performance.

The result for SOEs in Column (10) of Table 4 is significantly positive, suggesting AI can enhance SOEs' ESG performance. Conversely, Column (11) presents inconsistent results for non-SOEs, and the coefficient for AI_install does not meet the 10% significance threshold. Furthermore, the coefficients for SOEs are significantly higher than those for non-SOEs. Hence, compared to non-SOEs, AI exerts more pronounced effects on improving SOEs' ESG performance.

# 5. Underlying Mechanism

## *5.1. Intermediary Analysis*

### 5.1.1 *Analyst Attention*

The advancement of AI enhances analysts' capacity to evaluate enterprises with respect to environmental, social, governance, and other dimensions, thereby augmenting their proficiency in acquiring and monitoring related information. This development compels enterprises to intensify their initiatives in these domains. Consequently, it can be posited that AI may impact enterprise ESG performance by influencing analyst attention. To investigate this mediating mechanism, the present study constructs the following Model (3):

$$Attention_{jt} = \alpha_0 + \beta_1 AI_{jit} + \eta C_{jit} + u_j + v_t + \varepsilon_{jt} \quad (3)$$

where ***Attention*** represents analyst attention, which is quantified by the quantity of analysts monitoring the corresponding enterprises. The others align with Model (2).

The coefficients of both AI_install and AI_stock in Table 5 are significantly positive. Hence, a greater presence of AI within a city correlates with increased scrutiny and interest from analysts towards local enterprises. In conclusion, AI can improve ESG performance by increasing analyst attention. Thus, Hypothesis H2a is support**ed. In fact, AI** technological **advancements boost analysts' productivity through real-time data analysis and advanc**ed tools, enabling their precise ESG evaluations as well as automated reporting. And the assistance of AI to analysts enhances transparency to pressure enterprises toward ESG initiatives and incentivize enterprises to prioritize ESG performance.

### 5.1.2 *Digital transformation*

As an advanced technological innovation, AI offers technical assistance, financial facilitation, and strategic direction to enterprises undergoing digital transformation. Concurrently, the enhancements in production efficiency and information processing capabilities resulting from this digital transformation have enabled enterprises to attain superior performance in ESG performance. To test the intermediary role of digital transformation, this study develops Model (4).

$$Transformation_{jt} = \alpha_0 + \beta_2 AI_{jit} + \eta C_{jit} + u_j + v_t + \varepsilon_{jt} \quad (4)$$

where ***Transformation*** represents digital transformation, which is measured by the frequency of keywords associated with digital transformation within enterprise annual reports, utilizing log form methodologies, drawing on Wu et al. (2021). The others align with Model (2).

These coefficients of AI_install and AI_stock in Table 5 are significantly positive. It means that AI has significantly facilitated the advancement of digital transformation within enterprises. Hence, AI can improve enterprises' ESG performance by accelerating their digital transformation, and Hypothesis H2b is supported. In fact, AI can help accelerate enterprises' digital transformation via technological isomorphism, enhancing data integration coupled with advancing digital technology adoption. Furthermore, AI-driven digital transformation help elevate enterprise ESG performance by optimizing production chains, boosting resource efficiency, alongside reducing emissions, simultaneously fostering transparent management structures to align stakeholder interests.

**Table 5. Results of intermediary analysis**

| | Pressure: analyst attention | | Power: digital transformation | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| AI_install | 16.800*** | | 3.834*** | |
| | (5.404) | | (0.476) | |
| AI_stock | | 4.438*** | | 0.687*** |
| | | (1.183) | | (0.100) |
| Controls | Yes | Yes | Yes | Yes |
| Enterprise FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| N | 11,737 | 11,737 | 11,737 | 11,737 |
| $R^2$ | 0.678 | 0.679 | 0.791 | 0.791 |

Note: *** p < 0.01. Robust standard errors are in parentheses.

## *5.2. Regulatory Analysis*

### 5.2.1 *Marketization Level*

As the degree of marketization level increases, the behavior of enterprises becomes increasingly influenced by market competition. In environments characterized by high levels of marketization, enterprises tend to prioritize their public image, leading them to be more inclined to embrace their environmental and social responsibilities as a means of enhancing their competitiveness. This suggests that the marketization level may amplify AI's enhancement effect on ESG performance. To empirically evaluate this hypothesis, Model (5) has been developed for the purposes of this study.

$$ESG_{jt} = \alpha_0 + \lambda_1 AI_{jit} \times Marketization_{j<+\beta_3 AI_{jit}+\theta_1 Marketization_{j<+\eta C_{jit}+u_j+v_t+\varepsilon_{jt}} \quad (5)$$

where ***Marketization*** represents marketization level, which is gained from National Economic Research Institute (NERI)[9]. I represents province and the others align with Model (2).

[9] *NERI: http://www.neri.org.cn.*

The coefficients of AI_install×Marketization and AI_stock×Marketization in Table 6 are significantly positive. Hence, as marketization increases, the influence of AI on enhancing enterprise ESG performance is expected to intensify. Hence, our findings support Hypothesis H3a. In fact, marketization level acts as a catalyst for AI-driven ESG improvements by enabling freer resource flows, stronger property rights, and competitive markets. Specifically, advanced marketization attracts digital resources while reducing government intervention, forcing enterprises to adopt AI-enhanced ESG strategies. Complementing this, standardized ESG disclosure systems in mature markets create institutional pressures, thus embedding ESG priorities into corporate operations.

### 5.2.2 *Business Environment*

A conducive business environment facilitates enterprises in navigating a standardized legal framework and engaging in equitable market competition during their operational processes. This advantageous external context enhances the likelihood of enterprises to participate in ESG initiatives. Consequently, business environment may serve as a positive regulatory factor influencing the AI-ESG performance nexus. Hence, Model (6) is developed for the purpose of conducting relevant empirical tests.

$$ESG_{jt} = \alpha_0 + \lambda_2 AI_{jit} \times Business_{j<+\beta_4 AI_{jit}+\theta_2 Business_{j<+\eta C_{jit}+u_j+v_t+\varepsilon_{jt}} \quad (6)$$

where ***Business*** represents business environment, which is measured by the data from Wang et al (2020). l represents province and the other symbols are consistent with those in Model (2).

The coefficients of both AI_install×Business and AI_stock×Business in Table 6 are significantly positive. These findings evidence business environment serves as a supportive catalyst in AI' enhancement of ESG performance. Hence, our findings support Hypothesis H3b. In fact, a robust business environment strengthens AI's role in advancing ESG performance by fostering efficient governance, innovation protection, and financial access. Meanwhile, these institutional synergies create a self-reinforcing cycle where AI technological adoption and business environment jointly amplify enterprises' ESG performance.

**Table 6. Results of regulatory analysis**

| | Marketization level | | Business environment | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| AI_install×Marketization | 2.466*** | | | |
| | (0.585) | | | |
| AI_stock×Marketization | | 0.458*** | | |
| | | (0.132) | | |
| AI_install×Business | | | 16.668*** | |
| | | | (6.339) | |
| AI_stock×Business | | | | 3.876** |
| | | | | (1.598) |
| AI_install | 0.879 | | -0.698 | |
| | (2.947) | | (3.901) | |
| AI_stock | | 0.458 | | -0.252 |
| | | (0.672) | | (0.963) |
| Marketization | -0.148* | -0.167* | | |
| | (0.090) | (0.090) | | |
| Business | | | 0.856 | 0.874 |
| | | | (0.820) | (0.822) |

| | | | | |
|---|---|---|---|---|
| Controls | Yes | Yes | Yes | Yes |
| Enterprise FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| N | 11,737 | 11,737 | 11,737 | 11,737 |
| $R^2$ | 0.843 | 0.843 | 0.843 | 0.843 |

Note: *** p < 0.01; ** p < 0.05; * p < 0.1. Robust standard errors are in parentheses.

# 6. Conclusions and Implications

## 6.1. Conclusions

Enterprise ESG practices benefit sustainable development; however, enterprises' ESG performance frequently falls short due to elevated costs and externalities. In recent years, AI has created new opportunities for enhancing enterprise ESG performance. Consequently, this study examines how AI affects enterprise ESG performance, utilizing a dataset comprising Chinese 1,270 publicly listed enterprises across 187 cities from 2006 to 2019.

The findings indicate AI improves enterprise ESG performance across various robustness assessments. Besides, the enhancement effect exhibits heterogeneity. Specifically, AI demonstrates a significant capacity to enhance the Chinese enterprises' performance in E and S items, while it does not exert a notable effect on G item. Furthermore, this positive impact is particularly relevant to enterprises located in eastern and central cities, resource-based cities, high-tech industries, and SOEs. Additionally, the underlying mechanisms suggest that AI contributes to improved enterprise ESG performance by increasing analyst attention and facilitating digital transformation. Furthermore, marketization level and business environment can amplify the effectiveness of AI in enhancing enterprise ESG performance.

This study makes contributions to a deeper understanding of the AI-ESG nexus. However, certain limitations remain. Future research could be directed towards several key areas. First, how the implementation of AI technologies within enterprises impacts their ESG performance can be examined. As this study primarily considers the external urban AI level, future inquiries might focus on the internal application of AI within enterprises. Second, it is important to investigate how urban AI influences enterprise ESG investments. While this study emphasizes the outcomes of ESG initiatives, future research could consider the inputs involved in these processes.

## 6.2. Policy Implications

Firstly, the government should prioritize the enhancement of AI and its role in improving enterprise ESG performance. This study provides empirical evidences for governmental initiatives focused on AI development. It is essential for the government to facilitate advancements in AI, offer institutional support for technological innovation, and foster a collaborative framework for AI development. Furthermore, the government should encourage the deeper integration of AI into enterprise ESG practices and reinforce the non-economic responsibilities of enterprises in addressing social obligations, mitigating environmental degradation, and improving governance.

Secondly, the government should leverage AI capabilities to enhance analyst attention and facilitate digital transformation, thereby strengthening AI's contribution to enterprise ESG performance. It can be achieved through supportive policies aimed at nurturing, developing, and expanding the pool of professional analysts, with a particular focus on enhancing their technical expertise in AI. Moreover, the government should allocate resources and establish policies that incentivize and assist enterprises in adopting digital technologies, particularly those exemplified by AI, to accelerate the transformation.

Thirdly, the government should prioritize marketization level and business environment to strengthen AI' effects on enterprise ESG performance. This involves minimizing administrative interventions in the market, facilitating the unrestricted flow of production factors, and fostering competitive dynamics among enterprises. Additionally, the government should improve business environment by streamlining administrative approval processes, reducing the tax and fee burdens on enterprises, reinforcing legal protections for property rights, and promoting transparency in governmental oversight.

# References

Acemoglu, D. and Restrepo, P., 2020. Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, 128(6), pp.2188-2244. https://doi.org/10.1086/705716.

An, Y., Deng, K.B., Ding, Z. and Gao, F., 2023. The role of marketization on the linkage between misallocation and productivity dispersion: Evidence from China. *Singapore Economic Review*, 68(3), pp.761-795. https://doi.org/10.1142/S0217590819500292.

Babina, T., Fedyk, A., He, A.L. and Hodson, J., 2024. Artificial intelligence, firm growth, and product innovation. *Journal of Financial Economics*, 151, 103745. https://doi.org/10.1016/j.jfineco.2023.103745.

Bai, F.P., Shang, M.T. and Huang, Y.J., 2024. Corporate culture and ESG performance: Empirical evidence from China. *Journal of Cleaner Production*, 437, 140732. https://doi.org/10.1016/j.jclepro.2024.140732.

Cai, C., Tu, Y.Q. and Li, Z., 2023. Enterprise digital transformation and ESG performance. *Finance Research Letters*, 58, 104692. https://doi.org/10.1016/j.frl.2023.104692.

Chen, J., Wang, N., Lin, T.Z. Liu, B.L. and Hu, J., 2024. Shock or empowerment? Artificial intelligence technology and corporate ESG performance. *Economic Analysis and Policy*, 83, pp.1080-1096. https://doi.org/10.1016/j.eap.2024.08.004.

Chen, R.X. and Zhang, T.X., 2024. Artificial intelligence applications implication for ESG performance: can digital transformation of enterprises promote sustainable development? *Chinese Management Studies*. https://doi.org/10.1108/CMS-11-2023-0653.

Chen, Z.F. and Xie, G.X., 2022. ESG disclosure and financial performance: Moderating role of ESG investors. *International Review of Financial Analysis*, 83, 102291. https://doi.org/10.1016/j.irfa.2022.102291.

Deng, Y., Jiang, W.Y., Wang, Z.Y., 2023. Economic resilience assessment and policy interaction of coal resource oriented cities for the low carbon economy based on AI. Resources Policy, 82, 103522. https://doi.org/10.1016/j.resourpol.2023.103522.

Fan, Z.M., Chen, Y. and Mo, Y.F., 2024. Management myopia and corporate ESG performance. *International Review of Financial Analysis*, 92, 103071. https://doi.org/10.1016/j.irfa.2024.103071.

Fang, M.Y., Nie, H.H. and Shen, X.Y., 2023. Can enterprise digitization improve ESG performance? *Economic Modelling*, 118, 106101. https://doi.org/10.1016/j.econmod.2022.106101.

Fu, C., Luo, D.Y., Zhang, J.S. and Li, W.X., 2025. Tax incentives, marketization level, and corporate digital transformation. *International Review of Economics & Finance*, 97, 103777. https://doi.org/10.1016/j.iref.2024.103777.

Gao, D., Zhou, X.T. and Wan, J., 2024. Unlocking sustainability potential: The impact of green

finance reform on corporate ESG performance. *Corporate Social Responsibility and Environmental Management*, 31(5), pp.4211-4226. https://doi.org/10.1002/csr.2801.

Gao, W. and Liu, Z.B., 2023. Green credit and corporate ESG performance: Evidence from China. *Finance Research Letters*, 55, 103940. https://doi.org/10.1016/j.frl.2023.103940.

Guo, K., Bian, Y., Zhang, D.Y. and Ji, Q., 2024b. ESG performance and corporate external financing in China: The role of rating disagreement. *Research in International Business and Finance*, 69, 102236. https://doi.org/10.1016/j.ribaf.2024.102236.

Guo, X., Liu, H.R., Saleem, S.F. and Budu, R.A., 2024a. Empowering sustainable human development and economic growth: Evidence from developing world. *Romanian Journal of Economic Forecasting*, 27(2), pp.32-49..

Holmstrom, J., 2022. From AI to digital transformation: The AI readiness framework. *Business Horizons*, 65(3), pp.329-339. https://doi.org/10.1016/j.bushor.2021.03.006.

Huang, J., Han, F.F. and Li, Y., 2025. The impact of institutional investors' ESG concerns on corporate ESG disclosure: Evidence from site visits. *Finance Research Letters*, 76, 106957. https://doi.org/10.1016/j.frl.2025.106957.

Huang, Y.J., Liu, S.C., Gan, J.W., Liu, B.L. and Wu, Y.X., 2024. How does the construction of new generation of national AI innovative development pilot zones drive enterprise ESG development? Empirical evidence from China. *Energy Economics*, 140, 108011. https://doi.org/10.1016/j.eneco.2024.108011.

Huo, H. and Wang, Y., 2023. Research on the evolutionary game of multi-agent collaborative supervision of enterprise green behavior driven by big data. *Frontiers in Environmental Science*, 11, 1326322. https://doi.org/10.3389/fenvs.2023.1326322.

Imjai, N., Yordudom, T., Yaacob, Z., Saad, N.H.M. and Aujirapongpan, S., 2025. Impact of AI literacy and adaptability on financial analyst skills among prospective Thai accountants: The role of critical thinking. *Technological Forecasting and Social Change*, 210, 123889. https://doi.org/10.1016/j.techfore.2024.123889.

Johnson, K.N., 2019. Automating the risk of bias. *George Washington law review*, 87(5), pp.1214-1271..

Khurram, M.U., Chen, L.F., Abedin, M.Z., Adu, D.A., Lucey, B., 2024. ESG disclosure and internal pay gap: Empirical evidence from China. *International Review of Economics & Finance*, 92, pp.228-244. https://doi.org/10.1016/j.iref.2024.02.023.

Kuai, Y.C., Wang, P.W. and Huang, G.L., 2025. Corporate ESG performance and credit misallocation: Evidence from China. *Research in International Business and Finance*, 73, 102621. https://doi.org/10.1016/j.ribaf.2024.102621.

Lee, C.C., Hussain, J. and Abass, Q., 2025. An integrated analysis of AI-driven green financing, subsidies, and knowledge to enhance CO2 reduction efficiency. *Economic Analysis and Policy*, 85, pp.675-693. https://doi.org/10.1016/j.eap.2024.12.021.

Lee, C.C., Lu, M.T., Wang, C.W. and Cheng, C.Y., 2024. ESG engagement, country-level political risk and bank liquidity creation. *Pacific-Basin Finance Journal*, 83, 102260. https://doi.org/10.1016/j.pacfin.2024.102260.

Li, C.M., Xu, Y., Zheng, H., Wang, Z.Y., Han, H.T. and Zeng, L.E., 2023. Artificial intelligence, resource reallocation, and corporate innovation efficiency: Evidence from China's listed companies. *Resource Policy*, 81, 103324. https://doi.org/10.1016/j.resourpol.2023.103324.

Li, G.L., Ren, K.J., Qiao, Y.H. and Wu, B., 2024b. From framing to priming: How does media coverage promote ESG preferences of institutional investors. *Emerging Markets Review*, 63, 101220. https://doi.org/10.1016/j.ememar.2024.101220.

Li, S.Y., Younas, M.W., Maqsood, U.S. and Zahid, R.M.A., 2024a. Impact of AI adoption on ESG performance: Evidence from Chinese firms. *Energy & Environment*. https://doi.org/10.1177/0958305X241269041.

Lin, B.Q. and Zhu, Y.T., 2025. Does AI elevate corporate ESG performance? A supply chain perspective. *Business Strategy and the Environment*, 34(1), pp.586-597. https://doi.org/10.1002/bse.3999.

Liu, Y., Zhang, F.K. and Zhang, H., 2024. CEO foreign experience and corporate environmental, social, and governance (ESG) performance. *Business Strategy and the Environment*, 33(4), pp.3331-3355. https://doi.org/10.1002/bse.3647.

Luo, Y.G., Cui, H.J., Zhong, H.Y. and Wei, C.H., 2023. Business environment and enterprise digital transformation. *Finance Research Letters*, 57, 104250. https://doi.org/10.1016/j.frl.2023.104250.

Nollet, J., Filis, G., Mitrokostas, E., 2016. Corporate social responsibility and financial performance: A non-linear and disaggregated approach. *Economic Modelling*, 52, pp.400-407. https://doi.org/10.1016/j.econmod.2015.09.019.

Pu, X.H., Zeng, M. and Zhang, W.K., 2023. Corporate sustainable development driven by high-quality innovation: Does fiscal decentralization really matter? *Economic Analysis and Policy*, 78, pp.273-289. https://doi.org/10.1016/j.eap.2023.03.008.

Qian, S.M., 2024. The effect of ESG on enterprise value under the dual carbon goals: From the perspectives of financing constraints and green innovation. *International Review of Economics & Finance*, 93, pp.318-331. https://doi.org/10.1016/j.iref.2024.03.010.

Qin, L.H., Su, H.D., Su, C.W. and Qin, M., 2024b. The essential role of big data: Could it effectively mitigate non-performing loans? *Romanian Journal of Economic Forecasting*, 27(3), pp.140-160..

Qin, M., Wan, Y., Dou, J.Y. and Su, C.W., 2024a. Artificial Intelligence: Intensifying or mitigating unemployment? *Technology in Society*, 79, 102755. https://doi.org/10.1016/j.techsoc.2024.102755.

Qin, M., Chang, H. L., Su, C. W., Racataian, R. I., Craciun, A. F., 2024b. Substitution or Creation? Identifying the Role of Artificial Intelligence in Employment. *Technological and Economic Development of Economy*, 1-22.

Qin, M., Hu, W., Qi, X.Z., Chang, T., 2024c. "Do the benefits outweigh the disadvantages? Exploring the role of artificial intelligence in renewable energy", Energy Economics, 131, 107403. https://doi.org/10.1016/j.eneco.2024.107403.

Roger, T., 2024. Do financial analysts care about ESG. *Finance Research Letters*, 63, 105289. https://doi.org/10.1016/j.frl.2024.105289.

Song, M.L., Pan, H.T., Shen, Z.Y. and Tamayo-Verleene, K., 2024. Assessing the influence of artificial intelligence on the energy efficiency for sustainable ecological products value. *Energy Economics*, 131, 107392. https://doi.org/10.1016/j.eneco.2024.107392.

Su, C.W., Liu, F.Y., Stefea, P. and Umar, M., 2023b. Does technology innovation help to achieve carbon neutrality? *Economic Analysis and Policy*, 78, pp.1-14. https://doi.org/10.1016/j.eap.2023.01.010.

Su, C.W., Mirza, N., Umar, M., Chang, T.Y. and Albu, L.L., 2022. Resource extraction, greenhouse emissions, and banking performance. *Resources Policy*, 79, 103122. https://doi.org/10.1016/j.resourpol.2022.103122.

Su, C.W., Shao, X.F., Jia, Z.J., Nepal, R., Umar, M. and Qin, M. 2023a. The rise of green energy metal: Could lithium threaten the status of oil? *Energy Economics*, 121, 106651. https://doi.org/10.1016/j.eneco.2023.106651.

Taherizadeh, A. and Beaudry, C., 2023. An emergent grounded theory of AI-driven digital transformation: Canadian SMEs' perspectives. *Industry and Innovation*, 30(9), pp.1244-1273. https://doi.org/10.1080/13662716.2023.2242285.

Vezeteu, C.D., Dinca, M.S. and Stanciulescu, R.I., 2024. The influence of ESG on financial performance. Evidence from a combined cluster and panel regression analysis. *Romanian Journal of Economic Forecasting*, 27(4), pp.82-104..

Wan, G.C., Zhang, W.K. and Li, C., 2024. How does low-carbon city pilot policy catalyze companies toward ESG practices? Evidence from China. *Economic Analysis and Policy*, 81, pp.1593-1607. https://doi.org/10.1016/j.eap.2024.02.036.

Wang, J., Shu, T., Zhao, W.J. and Zhou, J.X., 2022. Research on Chinese consumers' attitudes analysis of big-data driven price discrimination based on machine learning. *Frontiers in Psychology*, 12, 803212. https://doi.org/10.3389/fpsyg.2021.803212.

Wang, J.K., Tian, H.W. and Zheng, P.H., 2025. The impact of artificial intelligence on corporate environmental investment. *IEEE Transactions on Engineering Management*, 72, pp.96-114. https://doi.org/10.1109/TEM.2024.3491940.

Wang, L.N. and Cao, L., 2024. Analyst attention and corporate green innovation. *Finance Research Letters*, 69, 104924. https://doi.org/10.1016/j.frl.2023.104924.

Wang, W.L., Sun, Q. and Zheng, M.B., 2021. Marketization level, fiscal input, and rural commercial bank performance. *Emerging Markets Finance and Trade*, 57(14), pp.4105-4120. https://doi.org/10.1080/1540496X.2020.1803825.

Wang, X.L., Fan, G. and Hu, L.P., 2020. *Business environment index for China's provinces 2020 report*. Beijing: Social Sciences Academic Press (China). In Chinese..

Wu, F., Hu, H.Z., Lin, H.Y. and Ren, X.Y., 2021. Enterprise digital transformation and capital market performance: empirical evidence from stock liquidity. *Journal of Management World*, 37(7), pp.130-144+10. In Chinese..

Yang, S.F. and Wu, H.N., 2022. The global organizational behavior analysis for financial risk management utilizing artificial intelligence. *Journal of Global Information Management*, 30(7), 292455. https://doi.org/10.4018/JGIM.292455.

You, X.H., Chen, C., Peng, K, and Li, Y.B., 2025. ESG disclosure quality and cost of debt. *Emerging Markets Review*, 64, 101219. https://doi.org/10.1016/j.ememar.2024.101219.

Yu, G.H., 2024. Digital transformation, human capital upgrading, and enterprise ESG performance: Evidence from Chinese listed enterprises. *Oeconomia Copernicana*, 15(4), pp.1465-1508. https://doi.org/10.24136/oc.3058.

Zeng, M. and Zhang, W.K., 2024. Green finance: The catalyst for artificial intelligence and energy efficiency in Chinese urban sustainable development. *Energy Economics*, 139, 107883. https://doi.org/10.1016/j.eneco.2024.107883.

Zhang, F., Yang, B. and Zhu, L., 2023b. Digital technology usage, strategic flexibility, and business model innovation in traditional manufacturing firms: The moderating role of the

institutional environment. *Technological Forecasting and Social Change*, 194, 122726. https://doi.org/10.1016/j.techfore.2023.122726.

Zhang, W.K., Fan, H.X. and Zhao, Q.W., 2023a. Seeing green: How does digital infrastructure affect carbon emission intensity? *Energy Economics*, 127, 107085. https://doi.org/10.1016/j.eneco.2023.107085.

Zhang, W.K., Fan, H.X. and Zeng, M., 2025. Unleashing the power of artificial intelligence: A game changer for urban energy efficiency in China. *Sustainable Cities and Society*, 126, 106372. https://doi.org/10.1016/j.scs.2025.106372.

Zhang, W.K. and Zeng, M., 2024. Is artificial intelligence a curse or a blessing for enterprise energy intensity? Evidence from China. *Energy Economics*, 134, 107561. https://doi.org/10.1016/j.eneco.2024.107561.

Zhang, W.K., Luo, Q. and Lin, X., 2024. Breaking boundaries: The influence of social insurance collection system reform on corporate innovation strategies. *Applied Economics*. https://doi.org/10.1080/00036846.2024.2405202.

Zhou, W., Zhuang, Y., Chen, Y., 2024. How does artificial intelligence affect pollutant emission: By improving energy efficiency or developing AI technology?. Energy Economics, 2024, 131: 107355. https://doi.org/10.1016/j.eneco.2024.107355.

Zhu, N.P., Zhang, S.Y. and Zhou, Y.Y., 2023. Impacts of environmental regulation on corporate ESG performance - Evidence from China. *Romanian Journal of Economic Forecasting*, 26(3), pp.62-82.