Received: 4 May 2023 | Revised: 5 February 2024 | Accepted: 21 February 2024

DOI: 10.1002/bse.3738

RESEARCH ARTICLE

Business Strategy and the Environment

WILEY

Revolutionizing green business: The power of academic directors in accelerating eco-innovation and sustainable transformation in China

Farid Ullah[1] | Ping Jiang[2] | Ahmed A. Elamer[3,4,5]

[1]School of Accounting, Xijing University, Xi'an City, China

[2]School of International Trade and Economics, University of International Business and Economics, Beijing, China

[3]Brunel Business School, Brunel University London, Uxbridge, UK

[4]UNEC Accounting and Finance Research Center, Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan

[5]Gulf Financial Center, Gulf University for Science and Technology, Mubarak Al-Abdullah Area/West Mishref, Kuwait, Kuwait

Correspondence
Ahmed A Elamer, Brunel Business School, Brunel University London, Kingston Lane, Uxbridge, London, UB8 3PH UK.
Email: ahmed.a.elamer@gmail.com

Funding information
This research was funded by the Funds for High-Level Talents of Xijing University (2019), [grant number XJ19B02]; National Natural Science Foundation of China [grant number 72073024], the Fundamental Research Funds for the Central Universities" in UIBE [grant number CXTD12-03].

Abstract

This study investigates the relationship between academic directors and corporate eco-innovation in Chinese A-listed firms in the context of the growing urgency of climate change. Based on the argument that academic directors bring advanced knowledge, skills, experience, and expertise to a corporate board and are more socially responsible and ethical, we hypothesized that academic directors would have a positive influence on corporate eco-innovation. We also examine how this nexus is moderated by pollutant firms and firms having qualified foreign institutional investors (QFIIs). Our results suggest that academic directors have a positive and significant impact on corporate eco-innovation. The findings remain robust even after employing alternate proxies for both independent and dependent variables, minimizing reverse causality and endogeneity concerns, and addressing self-selection bias through the entropy balancing method. Additionally, our study reveals that the positive nexus between academic directors and eco-innovation is more pronounced in pollutant firms and firms having QFIIs. This study contributes to the literature on corporate governance, eco-innovation, and emerging markets by providing evidence of the positive influence of academic directors on eco-innovation, highlighting the importance of their contribution to enhancing corporate governance mechanisms to promote environmentally friendly activities and sustainability practices. Furthermore, our findings offer insight into the role of QFIIs in strengthening the positive association between academic directors and eco-innovation, suggesting that foreign investors can support and encourage firms to adopt environmentally friendly practices for long-term benefits.

KEYWORDS
academic directors, China, corporate governance, eco-innovation, environmental sustainability, foreign institutional investors

Abbreviations: CNIPA, China National Intellectual Property Administration; CNRDS, Chinese Research Data Service; CSMAR, China Stock Market Research; EBM, Entropy balancing method; HEIs, Higher education institutions; QFIIs, Qualified foreign institutional investors; 2SLS, Two-stage least square.

1 | INTRODUCTION

In recent years, eco-innovation has emerged as a crucial political agenda worldwide, including in China, where efforts to implement green technologies have intensified. eco-innovation, encompassing processes and products that enhance energy efficiency and reduce environmental pollution, is a burgeoning area of research (Barbieri et al., 2020; Del Brío & Junquera, 2003). While scholars have identified various antecedents that significantly influence corporate eco-innovation (Fabrizi et al., 2018; Ha, 2021; Li et al., 2023; Nadeem et al., 2020), the field remains in its infancy. The extent to which directors promote corporate eco-innovation by providing their academic expertise is an open empirical enquiry, which has not been widely studied. This study aims to extend the existing literature by exploring whether directors with academic backgrounds significantly impact corporate eco-innovation within the Chinese context, employing the resource dependence perspective.

The resource dependence theory (Hillman & Dalziel, 2003; Pfeffer & Salancik, 1978) posits that the human and relational capital of directors—encompassing knowledge, skills, experience, and expertise—crucially optimizes corporate governance mechanisms and safeguards the interests of shareholders and stakeholders (Elmagrhi et al., 2019; Khatib et al., 2021). Prior research on board of directors suggests that academic directors are more likely to influence various corporate outcomes due to their analytical thinking, modern managerial and scientific knowledge, and higher social and ethical standards (Audretsch & Lehmann, 2006; Francis et al., 2015; Huang & Teklay, 2021; Jin et al., 2022). In addition, based on the view that academics are generally having comparatively higher social and ethical standards (Baumgarten, 1982; O'Connell, 1998; Tierney, 1997), Cho et al. (2017) argue that academic directors not only protect shareholders' interests but also helpful for corporate stakeholder such as the society for their role in enhancing sustainability. Therefore, based on these findings, we expect that directors' academic background can be an important determinant of corporate eco-innovation due to their modern managerial and scientific knowledge and higher social and ethical standards as compared to their counterparts.

While previous studies have focused on the role of senior management academic experience (He et al., 2021; Mahran & Elamer, 2023) and the impact of academic directors on general corporate innovation (Wang, 2020), this study distinguishes itself by specifically investigating the determinants of eco-innovation. Given the unique challenges and complexities surrounding eco-innovation (Barbieri et al., 2020; Del Brío & Junquera, 2003), understanding the role of directors' academic backgrounds in this context is vital.

Contextually, the Chinese setting offers a particularly compelling context for examining the relationship between directors' academic backgrounds and corporate eco-innovation. Following the implementation of green credit policies and environmental protection laws, China has experienced significant strides in various domains, including green patent growth and clean energy investment (Ullah et al., 2022; Yu et al., 2021). For example, after the implementation of the green credit policy in 2012 and the environmental protection law in 2014 to minimize the hazardous production strategy, China has made incredible progress in various domains. The China National Intellectual Property Administration (CNIPA) shows that the number of green patents showed a 14 times increase (from 16,000 to 223,000) from 2006 to 2017 (Yu et al., 2021). Similarly, to achieve carbon neutrality by 2060, out of a total of $755 billion in clean energy investment around the world in 2021, China accounted for $266 (35%) billion.[1] Also, since 1978, China has undergone significant transformation and has shortly become the second-largest Economy in the world (Jiang & Kim, 2015, 2020). Despite rapid Economic growth, protecting stakeholders' interests remains a critical concern for boards of directors, given the challenges posed by weaker laws and agency problems (Jiang & Kim, 2020).

The findings of this study indicate a positive and significant association between directors' academic backgrounds and corporate eco-innovation, particularly in polluting industries and firms with qualified foreign institutional investors (QFIIs). To ensure robustness, various methods were employed to address potential issues such as reverse causality, endogeneity, and selection bias. Overall, our findings corroborate our hypothesis that academic directors tend to enhance eco-innovation and also recommend that resource dependence perspective can better explain the presence of academic directors on a corporate board.

This study contributes to the existing literature in four key aspects. First, preceding studies are predominantly focused on the impact of directors' academic background on various outcomes including firm performance (Francis et al., 2015), corporate social responsibility (Cho et al., 2017), and minority shareholders expropriation (Huang & Teklay, 2021). Moreover, studies regarding the determinants of eco-innovation show that various factors including corporate governance (Chen et al., 2023; García-Sánchez et al., 2020; Nadeem et al., 2020; Quan et al., 2023) affect corporate eco-innovation. Therefore, based on the argument that academic directors are more knowledgeable, social, and ethical, this study is expected to enrich the literature regarding the consequences of directors' academic background and determinants of eco-innovation.

Second, mostly studies on academic directors in the Chinese context are limited to independent academic directors (Huang & Teklay, 2021; Jin et al., 2022; Pang et al., 2020). The prior literature suggests that independent directors in China are not effective monitors as firms appoint such directors to fulfill legal requirements (Jiang & Kim, 2015), and also most of these directors are rookies (less experienced), which limits their ability to effective monitoring (Bai & Yu, 2022; Chen et al., 2022; Ullah et al., 2023). Moreover, preceding studies recommend that special attributes of directors should be observed at board level and should not be restricted to independent directors (Giannetti et al., 2015; Wen et al., 2020). Therefore, we further contribute to the literature by analyzing how the proportion of all academic directors to the total board size affects eco-innovation.

[1]See for details: https://www.greenbiz.com/article/government-policy-spurs-investment-chinese-climate-tech.

Third, even though China is recently trying to move towards a greener economy (Ullah et al., 2022; Xiao & Wang, 2020). However, their aggressive production approach in the past has created serious environmental issues (air pollution, wastage of resources, and high amount of chemical discharge) and has adversely affected national and firm-level outcomes (He et al., 2016; Xiao & Wang, 2020; Yang & Liu, 2018). As the existing studies (Audretsch & Lehmann, 2006; Cho et al., 2017; Francis et al., 2015; Jin et al., 2022; Tierney, 1997) contend that academic directors are more ethical and social as compared to their other counterparts; therefore, we contribute to the prevailing literature by testing whether or not academic directors can work as an effective monitor to enhance eco-innovation in polluting firms.

Fourth, the proportion of QFIIs has shown a gradual increase after the implementation of a policy in 2002 that permits QFIIs to hold A-shares listed firms in China. However, still, the presence of QFIIs is quite low in China. Meanwhile, existing studies provide contrasting arguments (positive and negative) about their contribution to governance and their impact on various corporate outcomes (Cao et al., 2017; Huang & Zhu, 2015; Jiang & Kim, 2015; McGuinness et al., 2017). Therefore, based on these contrasting arguments, we further contribute by testing the moderating role of QFIIs in the nexus between academic directors and eco-innovation.

The remainder of the paper is organized as follows: Section 2 presents the literature review and hypotheses, Section 3 details the research design, Section 4 discusses the empirical findings, and Section 5 concludes with implications and directions for future research.

2 | LITERATURE REVIEW

2.1 | Determinants of eco-innovation

Eco-innovation, encompassing environmental or green innovation, refers to the development and implementation of green technologies that optimize resource utilization and mitigate environmental pollution (Barbieri et al., 2020; Del Brío & Junquera, 2003; Nadeem et al., 2020; Vasileiou et al., 2022). Current research posits that eco-innovation not only contributes to pollution and CO_2 reduction but also enhances shareholder value in the long term (Zhang et al., 2019). For instance, Vasileiou et al. (2022) establish a positive link between green innovation and firm performance in Italy, while Zaman et al. (2021) demonstrate that eco-innovation safeguards shareholder interests by reducing stock price crash risk.

Given the importance of eco-innovation for corporate stakeholders (Adomako & Nguyen, 2023; Bos-Brouwers, 2010; Al Frijat, Albawwat, & Elamer, 2023; Kazemi et al., 2023; Srouji et al., 2023; Tang et al., 2018), numerous countries have implemented various green financial policies to foster eco-innovation at both national and firm levels. Some studies have investigated the relationship between regulatory policies and eco-innovation to assess their effectiveness. Fabrizi et al. (2018), examining data from 23 European countries, find that market-based regulatory policies and participation in the European green research network significantly enhance eco-innovation. Hu et al. (2021) argue that China's 2012 green credit policy has substantially promoted eco-innovation. Additionally, governments often provide subsidies, including R&D support and discounted loans, to specific sectors to encourage eco-innovation and discourage pollution (Bai et al., 2019; Huang et al., 2019).

As eco-innovation demands substantial resources, organizational factors are also deemed critical drivers (Kim et al., 2021; Li et al., 2023). Kim et al. (2021) contend that firms operating in multiple countries gain a competitive edge over local firms in terms of operational risk, resources, and human capital, resulting in a positive association between corporate internationalization and eco-innovation. Li et al. (2023) propose that environmental, social, and governance activities within a firm can spur eco-innovation in peer firms due to the green spillover effect within the industry.

Considering that eco-innovative firms are viewed as more ethical and effective in protecting shareholder and stakeholder interests (Kunapatarawong & Martínez-Ros, 2016; Vasileiou et al., 2022; Zaman et al., 2021), existing literature has also investigated various governance mechanisms to determine their contributions to eco-innovation. Nadeem et al. (2020) analyze data from US-listed firms and discover a positive and significant relationship between board gender diversity and corporate eco-innovation. Chen et al. (2023) reveal that directors' foreign experience positively impacts eco-innovation in China, while Quan et al. (2023) report that CEO foreign experience enhances corporate eco-innovation. Furthermore, García-Sánchez et al. (2020) demonstrate that institutional ownership bolsters eco-innovation.

Although previous research has analyzed the effects of various governance mechanisms, including directors' attributes, on eco-innovation, no study has yet examined the impact of academic directors on eco-innovation. Academic directors, who are believed to possess up-to-date knowledge and hold higher social, ethical, and reputational standing, remain an underexplored area in eco-innovation research.

2.2 | Academic directors and corporate outcomes

The literature recognizes academic directors as being socially and morally more obligated compared to their non-academic counterparts, prompting researchers to investigate their roles on corporate boards and the effects on various corporate behaviors (Audretsch & Lehmann, 2006; Cho et al., 2017; Francis et al., 2015; Huang & Teklay, 2021; Jin et al., 2022). Audretsch and Lehmann (2006) emphasize that the likelihood of having academic directors on a board is influenced by geographic proximity to a university and industry. Francis et al. (2015) argue that a higher proportion of academic directors enhances firm performance, a finding supported by Liu (2020). In contrast, White et al. (2014) report that market reactions to the appointment of academic directors are relatively muted.

Huang et al. (2016) demonstrate that academic directors with accounting backgrounds contribute to improved financial reporting

quality, while Cho et al. (2017) reveal that firms with a higher proportion of academic directors are more likely to exhibit increased corporate social responsibility. Chen et al. (2019) argue that the unexpected resignation of academic directors is perceived as a loss by the market, as such resignations lead to reduced corporate stock returns—a result corroborated by Pang et al. (2020).

Huang and Teklay (2021) suggest that although academic independent directors protect minority shareholders, they simultaneously reduce a firm's investment efficiency. Jin et al. (2022) contend that academic independent directors enhance financial reporting quality, corporate social responsibility, and decrease agency costs and overinvestment activities, ultimately reducing stock price crash risk.

Despite the numerous studies investigating the impact of academic directors on various corporate outcomes, to the best of our knowledge, none have yet explored how academic directors influence eco-innovation. This gap in the literature presents an opportunity for further research in this area.

2.3 | Academic directors and eco-innovation

The resource dependency perspective (Pfeffer & Salancik, 1978) has been used to study the effect of corporate boards on various corporate outcomes. According to this theory, directors enhance a firm's legitimacy and public image by providing advice and counsel based on their knowledge, experience, expertise, and skills. Additionally, directors with diverse attributes contribute to firm-stakeholder linkages, access to resources, external relations, strategy formulation, and other significant decisions. In line with this view, the representation of academic professionals in managerial and directorial roles has garnered considerable attention (Audretsch & Lehmann, 2006; Chen et al., 2019; Cho et al., 2017; Francis et al., 2015; Jiang & Murphy, 2007). It is posited that academic professionals possess unique characteristics and are socially more obligated (Baumgarten, 1982; O'Connell, 1998; Tierney, 1997).

For instance, Baumgarten (1982) asserts that professors and academicians have responsibilities to various community groups, both within and outside the classroom, necessitating that they maintain high moral standards and pursue social benefits rather than personal gain. Tierney (1997) highlights that professors' and academics' fundamental responsibilities—teaching, research, and service to the university and community—ultimately lead to long-term positive societal impacts.

Empirical studies on academic directors suggest that they are more ethical and socially conscious, possessing up-to-date managerial and scientific knowledge to effectively protect shareholders' interests (Audretsch & Lehmann, 2006; Chen et al., 2019; Cho et al., 2017; Francis et al., 2015). For example, research indicates that a higher proportion of academic directors improves firm performance (Francis et al., 2015), financial reporting quality (Huang et al., 2016), and reduces stock price crash risk (Jin et al., 2022) and minority shareholder expropriation (Huang & Teklay, 2021). Furthermore, based on the argument that academics are more likely to contribute to the community (Baumgarten, 1982; Tierney, 1997), Cho et al. (2017) find that firms with a higher proportion of academic directors are more likely to engage in corporate social responsibility initiatives.

In the same vein, existing literature on eco-innovation posits that corporate governance factors, including board attributes, significantly influence eco-innovation (Chen et al., 2023; García-Sánchez et al., 2020; Nadeem et al., 2020). For instance, in line with the resource dependency perspective, prior studies suggest that board gender diversity (Nadeem et al., 2020), directors' foreign experience (Chen et al., 2023), CEO foreign experience (Quan et al., 2023), and institutional ownership (García-Sánchez et al., 2020) play significant roles in eco-innovation. However, these studies largely overlook the role of academic directors in eco-innovation, which is particularly important for two reasons.

First, with the growing global debate on climate and environmental issues among regulators, media, and the general public, firms must demonstrate a strong commitment to reducing environmental pollution through eco-innovation, transitioning from environmentally harmful production processes to eco-friendly alternatives. Second, engagement in eco-innovation not only reduces a firm's environmental impact but ultimately protects shareholders' interests, as such firms tend to enjoy higher long-term profits (Vasileiou et al., 2022) and a lower likelihood of stock price crash risk (Zaman et al., 2021).

In conclusion, drawing from the resource dependency theory, we argue that academic directors bring specialized knowledge, skills, and expertise to the boardroom. Furthermore, with their strong ethical and social values, academic directors are more attentive to the interests of all parties, including the community, and are likely to engage in activities (such as eco-innovation) that yield social benefits. Based on this reasoning, we propose the following hypothesis:

> **H1.** There is a positive and significant relationship between academic directors and corporate eco-innovation.

3 | RESEARCH DESIGN

3.1 | Sample

Our study's sample consists of A-listed firms from the Shenzhen and Shanghai stock exchanges for the period between 2008 and 2019. Data on eco-innovation was sourced from the Chinese Research Data Service (*CNRDS*), while data for the remaining variables (independent, moderating, and control) was obtained from the China Stock Market Research (*CSMAR*) database. Both of these databases have been extensively employed in previous studies (Chen et al., 2023; Jin et al., 2022; Li et al., 2023). The purpose of choosing A-share firms is to follow the argument of Giannetti et al. (2015) who stated that Chinese firms generally issue three types of shares, namely, A, B, and H shares. They further stated that A shares (B shares) were specifically issued for domestic (foreign) investors; however, foreign (domestic) investors were also allowed to hold A shares (B shares) since 2002

(March 2001). Additionally, a limited number of firms can issue H shares on the Hong stock exchanges; however, as per Giannetti et al. (2015), Chinese firms listed in overseas stock exchanges are generally not listed in the domestic market.

To ensure an accurate sample, we took the following steps: (1) excluded firms in the financial industry due to their different financial structure and regulations (a total of 105 observations); (2) eliminated ST, *ST, and PT firms; and (3) removed observations with missing data (a total of 235 observations). This process resulted in a final sample of 11,336 observations. To mitigate the impact of extreme values, we winsorized all continuous variables at the 1% and 99% levels.

3.2 | Eco-innovation

In line with previous studies (Chen et al., 2023; Hu et al., 2021; Li et al., 2023), we measured eco-innovation using two approaches. First, we calculated eco-innovation as the natural logarithm of 1 plus the total number of green patents filed by a firm in a given year. Second, for a robustness check, we measured eco-innovation as the natural logarithm of 1 plus the total number of green invention patents filed by a firm in a given year.

3.3 | Directors' academic background

In accordance with previous research (Cho et al., 2017; Liu, 2020), we assessed directors' academic backgrounds using two proxies. First, we calculated the proportion of academic directors by dividing the total number of academic directors by the total number of directors in a given year. Second, we used the total number of academic directors a firm has in a specific year as an alternative measure.

3.4 | Control variables

Drawing on prior research (Bilal et al., 2023; Cho et al., 2017; Ezeani et al., 2022; Ezeani, Kwabi, et al., 2023; Ezeani, Salem, et al., 2023; García-Sánchez et al., 2020; Javed et al., 2023; Kim et al., 2021; Li et al., 2023; Nadeem et al., 2020; Usman et al., 2023), we controlled for various factors that may significantly influence eco-innovation. For instance, Nadeem et al. (2020) emphasize the potential impact of board attributes on eco-innovation. Consequently, we incorporated three board-related variables: board size (total number of directors), board independence (total independent directors divided by total directors), and gender diversity (total female directors divided by total directors). Javed et al. (2023) contend that CEO characteristics also play a crucial role in corporate eco-innovation. As such, we considered three CEO characteristics: CEO age (natural log of the CEO's total age), CEO gender (a dummy variable equaling "1" if the CEO is female and "0" otherwise), and CEO duality (a dummy variable equaling "1" if the CEO also serves as board chairman and "0" otherwise). García-Sánchez et al. (2020) argue that a firm's ownership structure can affect corporate eco-innovation. We utilized two ownership-related variables: institutional ownership (number of shares held by institutional investors divided by total shares outstanding) and largest shareholder (number of shares held by the largest shareholder divided by total shares outstanding). Finally, we included firm-specific variables (Abdelkader et al., 2024; Al Frijat et al., 2023; Kazemi et al., 2023; Liu et al., 2023; Mahran & Elamer, 2023; Selmey & Elamer, 2023) such as leverage (total debt to total assets), return on assets (income before interest and taxes divided by total assets), market-to-book ratio (market value of equity divided by book value of equity), and firm size (log of a firm's total assets in a given year).

3.5 | Econometric model

We check the hypothesis of our study by using the below regression model with year and industry fixed effect.

$$\text{Eco}-\text{innovation}_{it} = b_0 + \beta_1 \text{Academic directors}_{it} + \beta_2 \text{Controls}_{it} + \beta_3 \text{Industry}_i + \beta_4 \text{Year}_t + \varepsilon_{it} \quad (1)$$

The suggested variables shown in the above equation have been briefly explained in Sections 3.2, 3.3, and 3.4, respectively.

4 | EMPIRICAL RESULTS

4.1 | Summary statistics

Figure 1 demonstrates a comparison of eco-innovation patent filings between firms with a higher versus lower proportion of academic directors. By defining high versus low proportion of academic directors based on the mean value, a high proportion of academic directors equals "1" if it is greater than the mean value of academic directors, and "0" otherwise. The results indicate that, on average, firms with a higher proportion of academic directors tend to file more patent applications related to eco-innovation than those with a lower proportion of academic directors. This observation supports the idea that the presence of academic directors on corporate boards positively influences the firm's engagement in eco-innovative activities, as they may bring valuable expertise, knowledge, and ethical perspectives that encourage the adoption of environmentally friendly practices.

Table 1 presents the summary statistics for the variables used in this study, including the total number of observations, mean, standard deviation, and percentile values (25th, 50th, and 75th). The average value of eco-innovation patents is 1.316, which aligns with previous studies in the Chinese context (Hu et al., 2021; Li et al., 2023). The average proportion of academic directors is 0.338, indicating that out of all directors in each firm, 33% are from academia. This value is consistent with the findings of Liu (2020). Furthermore, the results reveal

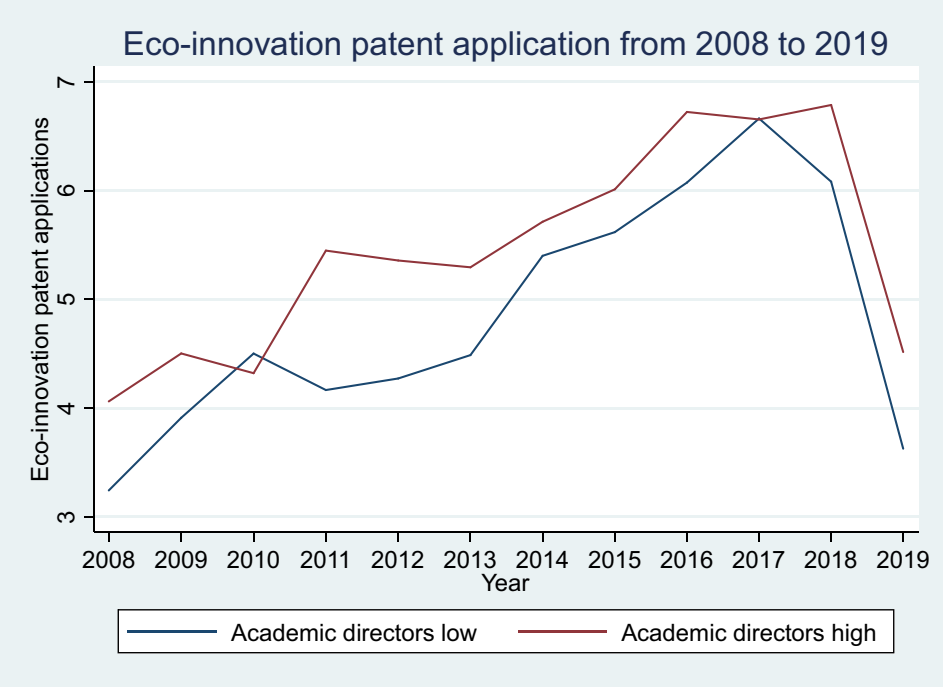

FIGURE 1 Eco-innovation patent applications. This figure indicates the average number of eco-innovations from 2008 to 2019 in firms having high versus low proportions of academic directors.

TABLE 1 Summary statistics.

Variables	N	Mean	SD	P25	P50	P75
G_Patents	11,336	1.316	0.936	0.693	1.099	1.792
Board Academic 1	11,336	0.338	0.179	0.222	0.333	0.444
Board Academic 2	11,336	3.079	1.725	2.000	3.000	4.000
Board size	11,336	9.250	2.580	8.000	9.000	9.000
Independence	11,336	0.374	0.0560	0.333	0.333	0.429
Female directors	11,336	0.129	0.121	0.000	0.111	0.222
CEO age	11,336	3.895	0.130	3.829	3.912	3.989
CEO female	11,336	0.0500	0.218	0.000	0.000	0.000
CEO duality	11,336	0.261	0.439	0.000	0.000	1.000
Institutions	11,336	0.0680	0.0610	0.0210	0.0520	0.099
Top one	11,336	0.353	0.155	0.232	0.333	0.456
Leverage	11,336	0.449	0.201	0.292	0.448	0.600
ROA	11,336	0.0360	0.0360	0.0180	0.0320	0.0520
M/B	11,336	1.886	0.995	1.241	1.583	2.170
Size	11,336	22.43	1.396	21.41	22.22	23.24
QFIIs	11,336	0.186	0.389	0.000	0.000	0.000

Note: This table presents the summary statistics of dependent, independent, control, and moderating variables.

that each firm has, on average, around 3 academic directors. The summary statistics for the control variables are in line with prior studies (Chen et al., 2023; Hu et al., 2021; Javed et al., 2023; Li et al., 2023), providing a strong foundation for comparing the results of this study with previous research.

Table 2 shows the univariate test results, comparing the mean value of eco-innovation in firms with a high versus low proportion of academic directors. The results show that firms with a higher proportion of academic directors tend to be more eco-innovative than their counterparts. The *T*-test values indicate that the difference in the mean values of eco-innovation is statistically significant. These findings support the hypothesis that firms with a higher proportion of academic directors are more likely to engage in eco-innovation compared to firms with a lower proportion of academic directors. This is consistent with the argument that academic directors bring unique knowledge, skills, and expertise to the boardroom, along with strong ethical and social values, which contribute to a higher level of eco-innovation within the firm.

TABLE 2 Univariate analysis.

Variables	*High Board Academic 1 = 1*		*High Board Academic 1 = 0*		*Differences*
	Observations	*Mean*	*Observations*	*Mean*	*T-value*
G_Patents	6286	1.335	5050	1.291	−2.502**
G_Inventions	6286	0.897	5050	0.813	−4.997***

Note: This table presents the mean difference in eco-innovation patents including total and invention applications filed in firms having high versus low proportions of academic directors.
*Significance level (two-tailed) at 10%.
**Significance level (two-tailed) at 5%.
***Significance level (two-tailed) at 1%.

Table 3 presents the results of the variance inflation factor (VIF) and correlation analyses for all variables considered in the study. As per Kennedy (2008), the sample of this study does not have a multicollinearity issue since all variables have VIF values less than the standard criteria of 10. The findings indicate that academic directors, board size, institutional ownership, largest shareholders, leverage, and firm size have a positive and significant association with eco-innovation. In contrast, gender diversity, return on assets, and market-to-book ratio exhibit a negative and significant impact on eco-innovation. CEO age, female CEO, and CEO duality show no association with eco-innovation. These results further support the hypothesis that academic directors positively influence eco-innovation in firms. Additionally, the findings highlight the complex relationship between various corporate governance factors and eco-innovation, with some variables promoting eco-innovation, while others might hinder it.

4.2 | Regression results

Table 4 presents the regression results of the effect of academic directors on eco-innovation. Columns (1) and (2) display the relationship between academic directors and eco-innovation without including control variables, while Columns (3) and (4) show the relationship after including control variables in the regression model. Columns (1) and (3) use the first proxy (Board Academic 1) for academic directors, and Columns (2) and (4) present the findings using the second proxy (Board Academic 2) for academic directors.

The regression coefficients of academic directors are all positive and significant at the 1% level, supporting our first hypothesis that academic directors tend to increase corporate eco-innovation. From an Economic significance perspective, Column (1) indicates that a one standard deviation increase in academic directors (Board Academic 1) leads to a 0.024 (=0.072 × 0.338) increase in eco-innovation. These findings are consistent with prior studies arguing that academic directors bring modern knowledge, skills, and expertise and are more socially and ethically oriented compared to their counterparts (Cho et al., 2017; Francis et al., 2015; Hillman & Dalziel, 2003; Jin et al., 2022; Pfeffer & Salancik, 1978).

Finally, the findings of all the control variables align with previous studies regarding the determinants of eco-innovation (Cho et al., 2017; García-Sánchez et al., 2020; Javed et al., 2023; Li et al., 2023; Nadeem et al., 2020).

4.3 | Robustness test

To ensure the robustness of our results, which show that academic directors enhance corporate eco-innovation, we employed two additional methods: using alternate proxies for eco-innovation and academic directors and addressing reverse causality by taking different lags of our main independent variable.

4.3.1 | Alternate proxies

Table 5 presents the results of robustness tests using alternate proxies for eco-innovation and academic directors. We measured eco-innovation by the total number of green invention patents (G_Inventions) filed by a firm in a given year. Additionally, we followed the approach of Cho et al. (2017) and measured academic directors by the proportion of directors with prior experience as a professor in a school or college to the total number of directors. The empirical results in Columns (1) and (2) indicate that academic directors have a positive and significant impact on corporate invention patents. Similarly, in Column (3), the results show that professors working in schools and colleges tend to increase corporate eco-innovation. Moreover, the coefficient values of all models are greater than those obtained in the main regression table.

These additional analyses further support our initial findings that academic directors contribute to enhancing corporate eco-innovation. The use of alternate proxies and the consistency of the results across different measures provide robust evidence for the positive relationship between academic directors and corporate eco-innovation.

4.3.2 | Standard errors clustered

To avoid time series and cross-sectional dependence, we followed the preceding literature (Gow et al., 2010; Thompson, 2011) and clustered

TABLE 3 Variance inflation factor and correlation analysis.

Variables	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. G_Patents	-	1													
2. Board Academic 1	1.04	0.024*	1												
3. Board size	1.21	0.022*	−0.104*	1											
4. Independence	1.17	0.027*	0.138*	−0.328*	1										
5. Female directors	1.09	−0.036*	−0.005	−0.076*	0.030*	1									
6. CEO age	1.07	0.012	0.067*	−0.006	0.049*	−0.001	1								
7. CEO female	1.06	−0.001	0.023*	−0.051*	0.058*	0.228*	−0.010	1							
8. CEO duality	1.11	−0.005	0.045*	−0.046*	0.081*	0.127*	0.147*	0.001	1						
9. Institutions	1.20	0.068*	0.058*	−0.081*	−0.004	−0.020*	−0.027*	−0.020*	−0.014	1					
10. Top one	1.15	0.032*	−0.034*	0.072*	0.057*	−0.051*	0.049*	0.008	−0.063*	−0.142*	1				
11. Leverage	1.58	0.139*	−0.090*	0.038*	0.012	−0.101*	0.030*	−0.056*	−0.172*	0.039*	0.098*	1			
12. ROA	1.23	−0.031*	0.009	0.165*	−0.038*	0.032*	−0.002	0.026*	0.070*	0.175*	0.120*	−0.261*	1		
13. M/B	1.38	−0.054*	0.091*	−0.144*	0.012	0.062*	−0.039*	0.017*	0.086*	0.179*	−0.141*	−0.334*	0.166*	1	
14. Size	1.89	0.241*	−0.048*	0.067*	0.068*	−0.144*	0.153*	−0.051*	−0.192*	0.158*	0.251*	0.539*	−0.022*	−0.419*	1

Note: This table presents the VIF values and correlation analysis between independent, dependent, and control variables.
*The significance level (two-tailed) at 10%, 5%, and 1%.

TABLE 4 Regression results.

Variables	(1) G_Patents	(2) G_Patents	(3) G_Patents	(4) G_Patents
Board Academic 1	0.072***		0.108***	
	[0.005]		[0.000]	
Board Academic 2		0.054***		0.035***
		[0.002]		[0.000]
Board size			0.012	0.010
			[0.182]	[0.296]
Independence			0.077	0.097
			[0.723]	[0.652]
Female directors			−0.110**	−0.111**
			[0.021]	[0.021]
CEO age			−0.263**	−0.261**
			[0.012]	[0.012]
CEO female			0.043	0.044
			[0.428]	[0.421]
CEO duality			0.099***	0.099***
			[0.000]	[0.000]
Institutions			0.141	0.144
			[0.439]	[0.431]
Top one			−0.050	−0.050
			[0.564]	[0.565]
Leverage			0.056	0.054
			[0.467]	[0.480]
ROA			−0.973**	−0.973**
			[0.024]	[0.024]
M/B			0.050***	0.051***
			[0.000]	[0.000]
Size			0.207***	0.207***
			[0.000]	[0.000]
Constant	0.924***	0.877***	−2.767***	−2.764***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Observations	11,336	11,336	11,336	11,336
R-squared	0.031	0.032	0.106	0.106

Note: This table presents the nexus between academic directors and eco-innovation. The *p*-values are reported in brackets. The variables are defined in Appendix A.
*The significance level (two-tailed) at 10%.
**The significance level (two-tailed) at 5%.
***The significance level (two-tailed) at 1%.

standard errors across firms and years. Here, we followed the similar approach employed in Tables 4 and 5 (main regression and alternate proxies) to analyze the association between academic directors and eco-innovation. The findings in Table 6 indicate that academic directors tend to have a positive and significant impact on eco-innovation for the proxies employed in the main regression model (Table 4) and alternative ones (Table 5) for both academic directors and eco-innovation. These findings further strengthen our argument that a higher proportion of academic directors on a corporate board are more likely to enhance corporate eco-innovation.

TABLE 5 Alternate proxies.

Variables	(1) G_Inventions	(2) G_Inventions	(3) G_Patents
Board Academic 1	0.207***		
	[0.000]		
Board Academic 2		0.075***	
		[0.000]	
Board Academic 3			0.140**
			[0.013]
Board size	0.015*	0.010	0.012
	[0.070]	[0.194]	[0.191]
Independence	0.271*	0.305**	0.083
	[0.057]	[0.035]	[0.703]
Female directors	−0.182***	−0.182***	−0.116**
	[0.003]	[0.003]	[0.016]
CEO age	−0.235***	−0.232***	−0.260**
	[0.006]	[0.007]	[0.015]
CEO female	0.011	0.013	0.043
	[0.829]	[0.811]	[0.428]
CEO duality	0.099***	0.100***	0.098***
	[0.000]	[0.000]	[0.000]
Institutions	0.154	0.157	0.141
	[0.353]	[0.345]	[0.441]
Top one	−0.107	−0.106	−0.050
	[0.303]	[0.305]	[0.572]
Leverage	−0.152**	−0.154**	0.055
	[0.023]	[0.021]	[0.478]
ROA	−1.110**	−1.108**	−0.974**
	[0.019]	[0.020]	[0.024]
M/B	0.076***	0.076***	0.051***
	[0.000]	[0.000]	[0.000]
Size	0.237***	0.237***	0.207***
	[0.000]	[0.000]	[0.000]
Constant	−3.933***	−3.925***	−2.764***
	[0.000]	[0.000]	[0.000]
Industry effect	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Observations	11,336	11,336	11,336
R-squared	0.119	0.118	0.106

Note: This table presents the nexus between academic directors and eco-innovation by using alternate proxies for both independent and dependent variables.
*The significance level (two-tailed) at 10%.
**The significance level (two-tailed) at 5%.
***The significance level (two-tailed) at 1%. The *p*-values are reported in brackets. The variables are defined in Appendix A.

4.3.3 | Negative binomial regression and firm fixed effect

We used negative binomial regression in Table 7 to address the issue that the total number of green patents is non-negative and discrete. In Columns (1) and (2), instead of log values, we employed a total number of green patents filed by a firm in a particular year as a proxy for eco-innovation. The empirical findings in these columns indicate that academic directors are positively and significantly associated with corporate eco-innovation activities.

Moreover, our findings in Table 4 might be driven due to certain unobservable firm-level factors that are not included in the model. One method to solve the issue of omitted-variable bias is to employ a firm-fixed effect model as it accounts for any unobservable characteristics that remain constant over time and capture variations with firms across different times. Thus, we re-estimate Equation (1) by replacing industry-fixed effects with firm-fixed effects. The empirical results in Table 7 Columns (3) and (4) indicate that both proxies of academic directors still have a positive and significant impact on eco-innovation. These findings show that our results are unlikely to be affected by unobservable and time-invariant firm-level factors that might be omitted.

4.3.4 | Reverse causality

In Table 8, we address the reverse causality issue by taking academic directors at three different year lags (from $t-1$ to $t-3$), following the recommendation of Chen et al. (2023). This approach helps to minimize the reverse causality issue in eco-innovation, which may arise due to the long R&D period of patents.

The results from columns (1) to (6) consistently show that academic directors have a positive and significant impact on eco-innovation, even after accounting for potential reverse causality issues. These findings further support our hypothesis and corroborate the robustness of our initial results.

4.4 | Endogeneity test

To mitigate the possible endogeneity arising from the correlation between academic directors and unobserved factors such as effective corporate governance and higher firm performance, we employ two approaches, namely, the instrumental variable and EBM.

4.4.1 | Instrumental variable

Two-stage least square (2SLS) regression is a powerful technique commonly used to address endogeneity concerns in empirical research. However, one major challenge is identifying a relevant instrumental variable that satisfies the exogeneity condition (Amin et al., 2023; Boulhaga et al., 2023). In this study, we tackle this issue by adopting an instrumental variable approach, following Jin et al. (2022), who propose that higher education institutions (HEIs) are suitable instrument for academic directors. We measure HEIs by taking the natural log of the total number of HEIs located in the province where a firm's headquarters are situated. The rationale for using HEIs

TABLE 6 Standard errors clustered.

Variables	(1) G_Patents	(2) G_Patents	(3) G_Inventions	(4) G_Inventions	(5) G_Patents
Board Academic 1	0.108**		0.207***		
	[0.023]		[0.000]		
Board Academic 2		0.035*		0.075***	
		[0.063]		[0.000]	
					0.140**
					[0.021]
Board size	0.012***	0.010**	0.015***	0.010***	0.012***
	[0.001]	[0.014]	[0.000]	[0.010]	[0.001]
Independence	0.077	0.097	0.271*	0.305*	0.083
	[0.657]	[0.577]	[0.096]	[0.061]	[0.634]
Female directors	−0.110	−0.111	−0.182***	−0.182***	−0.116*
	[0.114]	[0.113]	[0.007]	[0.007]	[0.097]
CEO age	−0.263***	−0.261***	−0.235***	−0.232***	−0.260***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
CEO female	0.043	0.044	0.011	0.013	0.043
	[0.261]	[0.254]	[0.761]	[0.735]	[0.267]
CEO duality	0.099***	0.099***	0.099***	0.100***	0.098***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Institutions	0.141	0.144	0.154	0.157	0.141
	[0.380]	[0.370]	[0.313]	[0.304]	[0.379]
Top one	−0.050	−0.050	−0.107*	−0.106*	−0.050
	[0.402]	[0.405]	[0.060]	[0.061]	[0.408]
Leverage	0.056	0.054	−0.152***	−0.154***	0.055
	[0.290]	[0.305]	[0.003]	[0.002]	[0.300]
ROA	−0.973***	−0.973***	−1.110***	−1.108***	−0.974***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
M/B	0.050***	0.051***	0.076***	0.076***	0.051***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.207***	0.207***	0.237***	0.237***	0.207***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	−2.767***	−2.764***	−3.933***	−3.925***	−2.764***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Industry effect	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes
Observations	11,336	11,336	11,336	11,336	11,336
R-squared	0.106	0.106	0.119	0.118	0.106

Note: This table presents the nexus between academic directors and eco-innovation by clustering standard errors across firms and years. The *p*-values are reported in brackets. The variables are defined in Appendix A.

*The significance level (two-tailed) at 10%.

**The significance level (two-tailed) at 5%.

***The significance level (two-tailed) at 1%.

as an instrument is that firms are likely to appoint academic directors from nearby schools and universities, which may reduce recruitment costs. The total number of HEIs in a province also reflects the education level and skills in the local market, which are not directly related to eco-innovation.

Our instrumental variable regression results, presented in Table 9, provide strong evidence that academic directors have a positive and significant impact on corporate eco-innovation. Columns (1) and (2) show the first-stage regression results, which indicate that HEIs are positively associated with the proportion of

TABLE 7 Negative binomial regression and firm fixed effect.

Variables	(1) G_Patents_Total	(2) G_Patents_Total	(3) G_Patents	(4) G_Patents
Board Academic 1	0.223***		0.088***	
	[0.000]		[0.001]	
Board Academic 2		0.084***		0.043***
		[0.000]		[0.000]
Board size	0.021**	0.015	0.006	0.002
	[0.018]	[0.106]	[0.245]	[0.713]
Independence	0.230	0.267	−0.021	−0.017
	[0.497]	[0.417]	[0.899]	[0.914]
Female directors	−0.261*	−0.256*	−0.127***	−0.029
	[0.052]	[0.059]	[0.004]	[0.617]
CEO age	−0.659***	−0.655***	−0.197***	−0.142*
	[0.005]	[0.005]	[0.001]	[0.059]
CEO female	0.019	0.021	0.055	0.050
	[0.823]	[0.803]	[0.126]	[0.135]
CEO duality	0.168***	0.169***	0.085***	0.093***
	[0.000]	[0.000]	[0.000]	[0.000]
Institutions	0.593*	0.592*	0.042	−0.057
	[0.074]	[0.076]	[0.876]	[0.824]
Top one	−0.237	−0.240	−0.147**	−0.247***
	[0.106]	[0.102]	[0.010]	[0.000]
Leverage	0.056	0.053	0.009	−0.090
	[0.624]	[0.642]	[0.905]	[0.261]
ROA	−1.210***	−1.209***	−0.363*	−0.584***
	[0.001]	[0.001]	[0.088]	[0.004]
M/B	0.103***	0.104***	0.037***	0.060***
	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.406***	0.407***	0.174***	0.209***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	−5.842***	−5.851***	−2.196***	−2.936***
	[0.000]	[0.000]	[0.001]	[0.000]
Industry effect	Yes	Yes	No	No
Year effect	Yes	Yes	Yes	Yes
Firm effect	No	No	Yes	Yes
Observations	11,336	11,336	11,336	11,336
R-squared	0.046	0.046	0.076	0.065

Note: This table presents the nexus between academic directors and eco-innovation by using negative binomial regression and firm-fixed effect. The *p*-values are reported in brackets. The variables are defined in Appendix A.

*The significance level (two-tailed) at 10%.

**The significance level (two-tailed) at 5%.

***The significance level (two-tailed) at 1%.

academic directors on corporate boards. The *F*-statistics for the first-stage regression are above the standard threshold of 10, indicating that our instrumental variable is relevant. Columns (3) and (4) show the second-stage regression results, which utilize the predicted values of academic directors obtained in the first stage. The findings reveal that academic directors significantly enhance corporate eco-innovation. These results demonstrate the robustness of our findings and provide further support for our argument that academic directors play a crucial role in promoting eco-innovation.

TABLE 8 Reverse causality.

Variables	(1) G_Patents	(2) G_Patents	(3) G_Patents	(4) G_Patents	(5) G_Patents	(6) G_Patents
Board Academic 1_{t-1}	0.040*					
	[0.077]					
Board Academic 1_{t-2}		0.094**				
		[0.048]				
Board Academic 1_{t-3}			0.146***			
			[0.003]			
Board Academic 2_{t-1}				0.041***		
				[0.002]		
Board Academic 2_{t-2}					0.075***	
					[0.006]	
Board Academic 2_{t-3}						0.077***
						[0.000]
Board size	−0.002	0.006	0.010	−0.004	0.001	0.006
	[0.922]	[0.729]	[0.621]	[0.798]	[0.948]	[0.785]
Independence	−0.194	−0.089	−0.015	−0.208	−0.104	−0.026
	[0.347]	[0.711]	[0.947]	[0.314]	[0.667]	[0.909]
Female directors	−0.173***	−0.162***	−0.155***	−0.167***	−0.154***	−0.151***
	[0.000]	[0.002]	[0.004]	[0.001]	[0.003]	[0.004]
CEO age	−0.239**	−0.217***	−0.275***	−0.243**	−0.222***	−0.276***
	[0.043]	[0.004]	[0.004]	[0.038]	[0.003]	[0.003]
CEO female	0.068	0.063	0.058	0.066	0.061	0.059
	[0.421]	[0.249]	[0.321]	[0.426]	[0.253]	[0.309]
CEO duality	0.108***	0.114***	0.115***	0.107***	0.113***	0.115***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Institutions	0.030	0.292*	0.258	0.027	0.285*	0.256
	[0.877]	[0.071]	[0.283]	[0.886]	[0.077]	[0.290]
Top one	−0.071	−0.083	−0.149	−0.073	−0.087	−0.156
	[0.524]	[0.570]	[0.384]	[0.517]	[0.554]	[0.367]
Leverage	0.035	0.091	0.173	0.039	0.093	0.173
	[0.737]	[0.376]	[0.110]	[0.706]	[0.363]	[0.109]
ROA	−0.932*	−0.949**	−0.785	−0.944**	−0.981**	−0.807
	[0.050]	[0.026]	[0.189]	[0.048]	[0.021]	[0.176]
M/B	0.079***	0.096***	0.126***	0.080***	0.098***	0.126***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Size	0.228***	0.249***	0.268***	0.229***	0.250***	0.270***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	−2.881***	−3.765***	−4.096***	−2.903***	−3.806***	−4.129***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7154	5935	4829	7154	5935	4829
R-squared	0.107	0.123	0.129	0.107	0.124	0.129

Note: This table presents the nexus between academic directors and eco-innovation by taking independent variables at different lags. The *p*-values are reported in brackets. The variables are defined in Appendix A.

*The significance level (two-tailed) at 10%.

**The significance level (two-tailed) at 5%.

***The significance level (two-tailed) at 1%.

TABLE 9 Instrumental variable.

	First stage		Second stage	
Variables	(1) Board Academic1	(2) Board Academic2	(3) G_Patents	(4) G_Patents
Schools	0.292***			
	[0.000]			
Schools		0.741***		
		[0.000]		
Board Academic 1			2.470***	
			[0.000]	
Board Academic 2				0.974***
				[0.000]
Board size	−0.002***	0.065***	0.019***	−0.051***
	[0.000]	[0.000]	[0.000]	[0.006]
Independence	0.367***	0.567***	−0.806**	−0.450*
	[0.000]	[0.000]	[0.013]	[0.072]
Female directors	−0.062***	−0.177***	0.047	0.066
	[0.000]	[0.000]	[0.579]	[0.446]
CEO age	0.080***	0.184***	−0.459***	−0.440***
	[0.000]	[0.000]	[0.000]	[0.000]
CEO female	0.011	0.015	0.014	0.028
	[0.157]	[0.452]	[0.741]	[0.508]
CEO duality	0.001	−0.007	0.099***	0.108***
	[0.853]	[0.477]	[0.000]	[0.000]
Institutions	0.167***	0.423***	−0.199	−0.198
	[0.000]	[0.000]	[0.296]	[0.299]
Top one	−0.001	−0.006	−0.039	−0.034
	[0.958]	[0.813]	[0.555]	[0.610]
Leverage	−0.054***	−0.117***	0.168**	0.148**
	[0.000]	[0.000]	[0.026]	[0.040]
ROA	−0.033	−0.129	−0.938***	−0.895***
	[0.506]	[0.319]	[0.001]	[0.001]
M/B	0.006***	0.013***	0.041***	0.045***
	[0.001]	[0.009]	[0.001]	[0.000]
Size	−0.001	−0.001	0.210***	0.206***
	[0.461]	[0.907]	[0.000]	[0.000]
Constant	−1.353***	−3.521***	−2.709***	−2.621***
	[0.000]	[0.000]	[0.000]	[0.000]
Industry effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
First stage F-stats	63.73	58.89		
Observations	11,336	11,336	11,336	11,336
R-squared	0.061	0.132	0.632	0.633

Note: This table presents the nexus between academic directors and eco-innovation by using the 2SLS method. The *p*-values are reported in brackets. The variables are defined in Appendix A.
*The significance level (two-tailed) at 10%.
**The significance level (two-tailed) at 5%.
***The significance level (two-tailed) at 1%.

TABLE 10 Entropy balancing method.

Panel A: Before entropy balancing						
	Treatment group High Board Academic 1 = 1			*Control group High Board Academic 1 = 0*		
Variables	*Mean*	*Variance*	*Skewness*	*Mean*	*Variance*	*Skewness*
Board size	9.11	6.143	1.853	9.424	7.247	1.639
Independence	0.376	0.003	1.749	0.370	0.002	1.623
Female directors	0.128	0.014	0.914	0.130	0.014	0.891
CEO age	3.90	0.016	−0.589	3.889	0.017	−0.496
CEO female	0.052	0.049	4.02	0.047	0.045	4.253
CEO duality	0.275	0.199	1.005	0.243	0.184	1.194
Institutions	0.071	0.003	1.186	0.064	0.003	1.421
Top one	0.350	0.023	0.551	0.355	0.024	0.485
Leverage	0.435	0.038	0.137	0.466	0.042	0.083
ROA	0.036	0.001	0.759	0.036	0.001	0.571
M/B	1.954	1.073	2.365	1.802	0.871	2.597
Size	22.38	1.944	0.781	22.48	1.95	0.660
Panel B: After entropy balancing						
	Treatment group (Green_Patents_High = 1)			*Control group (Green_Patents_High = 0)*		
Variables	*Mean*	*Variance*	*Skewness*	*Mean*	*Variance*	*Skewness*
Board size	9.11	6.143	1.853	9.11	6.924	1.709
Independence	0.376	0.003	1.749	0.376	0.003	1.58
Female directors	0.128	0.014	0.914	0.128	0.014	0.892
CEO age	3.90	0.016	−0.589	3.90	0.017	−0.461
CEO female	0.052	0.049	4.02	0.052	0.049	4.021
CEO duality	0.275	0.199	1.005	0.275	0.199	1.005
Institutions	0.071	0.003	1.186	0.071	0.004	1.267
Top one	0.350	0.023	0.551	0.350	0.023	0.498
Leverage	0.435	0.038	0.137	0.435	0.041	0.191
ROA	0.036	0.001	0.759	0.036	0.001	0.418
M/B	1.954	1.073	2.365	1.954	1.182	2.387
Size	22.38	1.944	0.781	22.38	1.891	0.727
Panel C: Entropy balancing regression results.						
Variables			**(1)** *G_Patents*			**(2)** *G_Patents*
High Board Academic 1			0.032*			
			[0.060]			
High Board Academic 2						0.033*
						[0.093]
Controls			Yes			Yes
Industry effect			Yes			Yes
Year effect			Yes			Yes
Observations			11,336			11,336
R-squared			0.106			0.071

Note: This table presents the nexus between academic directors and eco-innovation by using EBM. The *p*-values are reported in brackets. The variables are defined in Appendix A.

*The significance level (two-tailed) at 10%.

**The significance level (two-tailed) at 5%.

***The significance level (two-tailed) at 1%.

4.4.2 | Entropy balancing method

We adopted the entropy balancing method (EBM) to address self-selection bias and further strengthen the robustness of our results. This method enables us to attain a higher degree of covariate balance and retain valuable information by using a reweighting approach that directly integrates the covariate into the weight function applied to the scheme unit (Hainmueller & Xu, 2013). To achieve covariate balance, we converted our independent variable into a binary outcome of high academic directors, where a value of "1" indicates firms containing academic directors above the mean value and "0" indicates firms having academic directors below the mean value. Notably, a prerequisite for using the EBM method is that the independent variable must be binary.

Table 10 presents the EBM results, with Panels A and B showing the treatment and control group before and after entropy balancing. The treatment group comprises firms with academic directors above the mean value, while the control group comprises firms with academic directors below the mean value. Comparing the covariates of the treatment and control firms in Panel B reveals that all covariates achieve matching, unlike in Panel A, where there was a significant difference between the treated and control groups. Regression results in Panel C after applying the balancing method confirm that academic directors have a positive and significant impact on corporate eco-innovation, further validating our hypothesis that academic directors enhance corporate eco-innovation. Overall, the EBM approach strengthens our findings by addressing potential self-selection bias.

4.5 | Further analysis

4.5.1 | The role of academic directors in polluting firms

We develop the following model to test the role of academic directors in eco-innovation in polluting firms.

$$\begin{aligned} \text{Eco}-\text{innovation}_{it} = {} & b_0 + \beta_1 \textit{Academic directors}_{it} + \beta_2 \textit{Polluting firms}it \\ & + \beta_3 \textit{Academic directors}it * \textit{Polluting firms}it + \beta_4 \text{Controls}_{it} \\ & + \beta_5 \text{Industry}_i + \beta_6 \text{Year}_t + \varepsilon_{it} \quad (2) \end{aligned}$$

The importance of addressing environmental issues in heavily polluting industries in China has been widely recognized in the literature (Ullah et al., 2022; Xiao & Wang, 2020). These industries have been found to contribute to air pollution, natural habitat degradation, and resource wastage, leading to adverse outcomes for both society and firms. Given the social responsibility and knowledge of academic directors (Cho et al., 2017; Francis et al., 2015; Jin et al., 2022), we argue that they can play a vital role in guiding and directing firms to engage in environmentally friendly activities to mitigate the adverse consequences of pollution in heavily polluting industries.

To test this hypothesis, we examined the impact of academic directors on eco-innovation in heavily polluting industries, as defined by a binary variable in Table 11. Our findings from Columns (1) to (4) indicate that academic directors have a significant positive impact

TABLE 11 The impact of academic directors on eco-innovation in pollutant firms.

Variables	(1) *G_Patents*	(2) *G_Patents*	(3) *G_Patents*	(4) *G_Patents*
Board Academic 1	−0.003		−0.014	
	[0.951]		[0.804]	
Pollutant firms	−0.213***	−0.231***	−0.271***	−0.273***
	[0.000]	[0.000]	[0.000]	[0.000]
Board Academic1 × Pollutant firms	0.196***		0.324***	
	[0.001]		[0.000]	
Board Academic2		0.031		0.006
		[0.156]		[0.595]
Board Academic2 × Pollutant firms		0.064*		0.086***
		[0.067]		[0.000]
Controls	No	No	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Observations	11,336	11,336	11,336	11,336
R-squared	0.036	0.036	0.112	0.111

Note: This table presents the nexus between academic directors and eco-innovation in pollutant firms. The *p*-values are reported in brackets. The variables are defined in Appendix A.
*The significance level (two-tailed) at 10%.
**The significance level (two-tailed) at 5%.
***The significance level (two-tailed) at 1%.

on eco-innovation in these industries, supporting our argument that they can play a crucial role in enhancing corporate environmental performance in heavily polluting industries.

Overall, our study highlights the importance of academic directors in promoting eco-innovation in heavily polluting industries in China, where environmental concerns have become increasingly pressing. The findings suggest that firms in these industries can benefit from the expertise and social responsibility of academic directors to improve their environmental performance and mitigate the adverse consequences of pollution.

4.5.2 | The role of academic directors in QFII firms

We have developed the following model to test the role of academic directors on eco-innovation in firms having QFIIs.

$$\begin{aligned}\text{Eco}-\text{innovation}_{it} &= b_0 + \beta_1 \textit{Academic directors}_{it} + \beta_2 \textit{QFIIsit} \\ &+ \beta_3 \textit{Academic directorsit} * \textit{QFIIsit} + \beta_4 \text{Controls}_{it} \\ &+ \beta_5 \text{Industry}_i + \beta_6 \text{Year}_t + \varepsilon_{it} \quad (3)\end{aligned}$$

Since 2002, the proportion of QFIIs has gradually expanded after the implementation of a policy where an investing quota was assigned to them. The existing literature suggests that foreign investors play a vital role in affecting corporate strategies either through their monitoring abilities (Choe et al., 1999; Huang & Shiu, 2009; Luong et al., 2017) or by supporting the presence of those directors at the corporate board who can bring long term benefits and sometimes exert direct influence on them to achieve desirable objectives (Desender et al., 2016; Jeon & Ryoo, 2013). Consistent with this argument, by analyzing the role of QFIIs in affecting various corporate outcomes, the prior literature provides contrasting arguments in the Chines context (Cao et al., 2017; Huang & Zhu, 2015; Jiang & Kim, 2015). For example, on the one hand, it is believed that QFIIs tend to enhance monitoring abilities and improve corporate governance thereby positively contributing to the Chinese context (Cao et al., 2017; Huang & Zhu, 2015). On the other hand, it is argued that QFIIs may not be effective in exerting oversight functions in the Chinese context due to their low proportion of shareholding (1.4%) and dispersed ownership (Jiang & Kim, 2015). Similarly, McGuinness et al. (2017) find an insignificant association between QFIIs and corporate social performance. Xu et al. (2023) check the nexus between institutional investors and eco-innovation and find that domestic institutional investors tend to enhance eco-innovation while the effect of QFIIs is insignificant. Therefore, on one hand, as eco-innovation brings long-term benefits to the shareholders and stakeholders, and academic directors might be a tool to enhance eco-innovation due to their positive contribution to society, we argue that QFIIs can further strengthen the positive nexus between academic directors and eco-innovation.

Consistent with our argument, in Table 12, we check the moderating role of QFIIs in the nexus between academic directors and eco-innovation. We followed prior studies (McGuinness et al., 2017) and measured QFIIs by a dummy variable equal to "1" if QFIIs hold the

TABLE 12 The impact of academic directors on eco-innovation in QFII firms.

Variables	(1) *G_Patents*	(2) *G_Patents*	(3) *G_Patents*	(4) *G_Patents*
Board Academic 1	0.027		0.078***	
	[0.431]		[0.005]	
QFIIs	−0.011	−0.048	−0.094***	−0.114***
	[0.721]	[0.326]	[0.002]	[0.007]
Board Academic1 × QFIIs	0.252**		0.169**	
	[0.011]		[0.017]	
Board Academic 2		0.037***		0.025***
		[0.004]		[0.003]
Board Academic 2 × QFIIs		0.092**		0.058*
		[0.050]		[0.084]
Controls	No	No	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Observations	11,336	11,336	11,336	11,336
R-squared	0.033	0.033	0.106	0.106

Note: This table presents the nexus between academic directors and eco-innovation in firms having QFIIs. The *p*-values are reported in brackets. The variables are defined in Appendix A.
*The significance level (two-tailed) at 10%.
**The significance level (two-tailed) at 5%.
***The significance level (two-tailed) at 1%.

shares of a firm in a given year and "0" if vice versa. The findings from Columns (1) to (4) show that the interaction term between academic directors and QFIIs (*Board Academic1* × *QFIIs* and *Board Academic2* × *QFIIs*) is positive and significant, which suggests that QFIIs strengthen the positive association between academic directors and eco-innovation. These findings support our argument that QFIIs may rely on academic directors to enhance eco-innovation in order to get long-term benefits.

5 | CONCLUSION

This study aims to investigate the relationship between academic directors and corporate eco-innovation in Chinese A-listed firms. Based on the argument that academic directors bring advanced knowledge, skills, experience, and expertise to a corporate board, and are more socially responsible and ethical, we hypothesized that academic directors would have a positive influence on corporate eco-innovation. We also examine how this nexus works in pollutant firms and firms having QFIIs.

Our results suggest that academic directors do have a positive and significant impact on corporate eco-innovation. The findings remain robust even after employing alternate proxies for both independent and dependent variables, minimizing reverse causality and endogeneity concerns, and addressing self-selection bias through EBM. Additionally, our study reveals that the positive nexus between academic directors and eco-innovation is more pronounced in pollutant firms and firms having QFIIs.

This study contributes to the literature on corporate governance, eco-innovation, and emerging markets in several ways. First, it provides evidence of the positive influence of academic directors on eco-innovation, highlighting the importance of their contribution to enhancing corporate governance mechanisms. Second, it reveals that pollutant firms and firms having QFIIs can benefit more from having academic directors on their board, as they face higher environmental and social responsibility pressures. Third, our findings offer insight into the role of QFIIs in strengthening the positive association between academic directors and eco-innovation, suggesting that foreign investors can support and encourage firms to adopt environmentally friendly practices for long-term benefits. Therefore, the study offers practical implications for policymakers, corporate boards, and investors. Policymakers might consider the introduction of incentives for firms that diversify their board composition to include academic directors, recognizing their positive impact on eco-innovation. Such incentives could take the form of tax advantages, grants for sustainable projects, or preferential treatment in governmental contracts. Corporate boards are encouraged to seek academic directors proactively, whose expertise in research and ethics can significantly contribute to eco-innovation initiatives, thereby enhancing the firm's reputation and potentially its market performance. Investors could also consider the presence of academic directors as a criterion in their investment decision-making process, given the associated benefits of fostering a culture of innovation and environmental responsibility within firms. These specific actions are suggested to leverage the insights from our study to promote sustainable practices across the corporate landscape.

Despite its contributions, this study has some limitations. The study only focuses on Chinese A-listed firms, which limits the generalizability of the findings and cannot be generalized to other emerging markets or developed economies. Moreover, our study does not consider the impact of other types of directors, such as independent directors, on eco-innovation. Also, the selected timeframe was intentional to avoid the confounding effects of the COVID-19 pandemic on eco-innovation activities and corporate governance, which could have introduced significant anomalies unrelated to the core dynamics we aimed to study. While our findings provide meaningful insights into the relationship between academic directors and eco-innovation in non-financial industries, they may not be directly applicable to the financial sector due to their distinct characteristics. Finally, the study is limited to examining the impact of academic directors on eco-innovation only and does not investigate the impact of eco-innovation on other firm-level outcomes such as financial performance, and risk management.

Future research can extend this study in several ways. First, future research could delve into the influence of academic directors on other crucial firm-level outcomes, such as tax avoidance and CEO compensation. Investigations might consider how the scholarly expertise and ethical standards of academic directors affect financial and governance decisions that can impact shareholder and stakeholder value. Mechanisms such as enhanced corporate transparency, improved strategic decision-making, and increased ethical considerations could serve as focal points of this research. Second, as eco-innovation continues to emerge as a field of study, there is a rich opportunity to explore novel antecedents such as organizational culture, employee engagement in sustainability, and the role of technological advancements. Similarly, the consequences of eco-innovation could be broadened to include its impact on firm reputation, legal compliance, and competitive advantage. Third, building on our study's focus on QFIIs, subsequent research might evaluate the influence of various other institutional investors, such as pension funds, hedge funds, and mutual funds, on the relationship between academic directors and eco-innovation. This could illuminate how different investment philosophies and pressures shape corporate eco-innovation strategies. Fourth, to address the external validity of our findings, cross-country studies are essential. Such research could compare the impact of academic directors on eco-innovation in different regulatory, cultural, and economic environments to assess the generalizability of our conclusions. This approach would also allow for the examination of how varying levels of environmental regulation and governance norms across countries influence the eco-innovation dynamic. Fifth, investigating the period following 2019 would offer insights into whether the trends identified in our study hold true in the face of recent economic, environmental, and technological changes. This is especially pertinent given the global shifts prompted by the COVID-19 pandemic, which may have altered the landscape of corporate governance and innovation. Lastly, while our study quantified the presence of academic directors, future research could qualitatively assess the impact of these directors' expertise and influence. Examining factors such as the directors' academic disciplines,

publication records, and active involvement in sustainability initiatives could provide a deeper understanding of how their quality influences eco-innovation.

CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest.

DATA AVAILABILITY STATEMENT

Data are available on request from the authors.

ETHICS APPROVAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors.

ORCID

Farid Ullah https://orcid.org/0000-0002-8259-5110
Ahmed A. Elamer https://orcid.org/0000-0002-9241-9081

REFERENCES

Abdelkader, M. G., Gao, Y., & Elamer, A. A. (2024). Board gender diversity and ESG performance: The mediating role of temporal orientation in South Africa context. *Journal of Cleaner Production*, *440*, 140728. https://doi.org/10.1016/J.JCLEPRO.2024.140728

Adomako, S., & Nguyen, N. P. (2023). Green creativity, responsible innovation, and product innovation performance: A study of entrepreneurial firms in an emerging economy. *Business Strategy and the Environment*, *32*, 4413–4425. https://doi.org/10.1002/BSE.3373

Al Frijat, Y. S., Albawwat, I. E., & Elamer, A. A. (2023). Exploring the mediating role of corporate social responsibility in the connection between board competence and corporate financial performance amidst global uncertainties. *Corporate Social Responsibility and Environmental Management*, *31*(2), 1079-1095. https://doi.org/10.1002/CSR.2623

Amin, A., Ali, R., ur Rehman, R., & Elamer, A. A. (2023). Gender diversity in the board room and sustainable growth rate: The moderating role of family ownership. *Journal of Sustainable Finance & Investment*, *13*(4), 1577–1599. https://doi.org/10.1080/20430795.2022.2138695

Audretsch, D. B., & Lehmann, E. (2006). Entrepreneurial access and absorption of knowledge spillovers: Strategic board and managerial composition for competitive advantage. *Journal of Small Business Management*, *44*(2), 155–166. https://doi.org/10.1111/j.1540-627X.2006.00161.x

Bai, M., & Yu, C. F. J. (2022). Rookie directors and corporate fraud. *Review of Corporate Finance*, *2*(1), 99–150. https://doi.org/10.1561/114.00000012

Bai, Y., Song, S., Jiao, J., & Yang, R. (2019). The impacts of government R&D subsidies on green innovation: Evidence from Chinese energy-intensive firms. *Journal of Cleaner Production*, *233*, 819–829. https://doi.org/10.1016/j.jclepro.2019.06.107

Barbieri, N., Marzucchi, A., & Rizzo, U. (2020). Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones? *Research Policy*, *49*(2), 103901. https://doi.org/10.1016/j.respol.2019.103901

Baumgarten, E. (1982). Ethics in the academic profession: A Socratic view. *The Journal of Higher Education*, *53*(3), 282–295. https://doi.org/10.1080/00221546.1982.11780454

Bilal, Komal, B., Ezeani, E., Usman, M., Kwabi, F., & Ye, C. (2023). Do the educational profile, gender, and professional experience of audit committee financial experts improve financial reporting quality? *Journal of International Accounting, Auditing and Taxation*, *53*, 100580. https://doi.org/10.1016/J.INTACCAUDTAX.2023.100580

Bos-Brouwers, H. E. J. (2010). Corporate sustainability and innovation in SMEs: Evidence of themes and activities in practice. *Business Strategy and the Environment*, *19*(7), 417–435. https://doi.org/10.1002/bse.652

Boulhaga, M., Bouri, A., Elamer, A. A., & Ibrahim, B. A. (2023). Environmental, social and governance ratings and firm performance: The moderating role of internal control quality. *Corporate Social Responsibility and Environmental Management*, *30*(1), 134–145. https://doi.org/10.1002/csr.2343

Cao, L., Du, Y., & Hansen, J. Ø. (2017). Foreign institutional investors and dividend policy: Evidence from China. *International Business Review*, *26*(5), 816–827. https://doi.org/10.1016/j.ibusrev.2017.02.001

Chen, J., Fan, Y., & Zhang, X. (2022). Rookie independent directors and corporate fraud in China. *Finance Research Letters*, *46*, 102411. https://doi.org/10.1016/j.frl.2021.102411

Chen, J., Garel, A., & Tourani-Rad, A. (2019). The value of academics: Evidence from academic independent director resignations in China. *Journal of Corporate Finance*, *58*, 393–414. https://doi.org/10.1016/j.jcorpfin.2019.06.003

Chen, W., Zhu, Y., & Wang, C. (2023). Executives' overseas background and corporate green innovation. *Corporate Social Responsibility and Environmental Management*, *30*(1), 165–179. https://doi.org/10.1002/csr.2345

Cho, C. H., Jung, J. H., Kwak, B., Lee, J., & Yoo, C. Y. (2017). Professors on the board: Do they contribute to society outside the classroom? *Journal of Business Ethics*, *141*, 393–409. https://doi.org/10.1007/s10551-015-2718-x

Choe, H., Kho, B. C., & Stulz, R. M. (1999). Do foreign investors destabilize stock markets? The Korean experience in 1997. *Journal of Financial Economics*, *54*(2), 227–264. https://doi.org/10.1016/S0304-405X(99)00037-9

Del Brío, J. Á., & Junquera, B. (2003). A review of the literature on environmental innovation management in SMEs: Implications for public policies. *Technovation*, *23*(12), 939–948. https://doi.org/10.1016/S0166-4972(02)00036-6

Desender, K. A., Aguilera, R. V., López puertas-Lamy, M., & Crespi, R. (2016). A clash of governance logics: Foreign ownership and board monitoring. *Strategic Management Journal*, *37*(2), 349–369. https://doi.org/10.1002/smj.2344

Elmagrhi, M. H., Ntim, C. G., Elamer, A. A., & Zhang, Q. (2019). A study of environmental policies and regulations, governance structures, and environmental performance: The role of female directors. *Business Strategy and the Environment*, *28*(1), 206–220. https://doi.org/10.1002/bse.2250

Ezeani, E., Kwabi, F., Salem, R., Usman, M., Alqatamin, R. M. H., & Kostov, P. (2023). Corporate board and dynamics of capital structure: Evidence from UK, France and Germany. *International Journal of Finance and Economics*, *28*(3), 3281–3298. https://doi.org/10.1002/IJFE.2593

Ezeani, E., Salem, R., Kwabi, F., Boutaine, K., Bilal, & Komal, B. (2022). Board monitoring and capital structure dynamics: Evidence from bank-based economies. *Review of Quantitative Finance and Accounting*, *58*(2), 473–498. https://doi.org/10.1007/S11156-021-01000-4/TABLES/10

Ezeani, E., Salem, R. I. A., Usman, M., Kwabi, F., & Bilal. (2023). Board characteristics and corporate cash holding: Evidence from the UK, France and Germany. *International Journal of Accounting and Information Management*, *31*(3), 413–439. https://doi.org/10.1108/IJAIM-09-2022-0184/FULL/XML

Fabrizi, A., Guarini, G., & Meliciani, V. (2018). Green patents, regulatory policies and research network policies. *Research Policy*, *47*(6), 1018–1031. https://doi.org/10.1016/j.respol.2018.03.005

Francis, B., Hasan, I., & Wu, Q. (2015). Professors in the boardroom and their impact on corporate governance and firm performance. *Financial Management*, *44*(3), 547–581. https://doi.org/10.1111/fima.12069

García-Sánchez, I. M., Aibar-Guzmán, C., & Aibar-Guzmán, B. (2020). The effect of institutional ownership and ownership dispersion on eco-innovation. *Technological Forecasting and Social Change*, *158*, 120173. https://doi.org/10.1016/j.techfore.2020.120173

Giannetti, M., Liao, G., & Yu, X. (2015). The brain gain of corporate boards: Evidence from China. *The Journal of Finance*, *70*(4), 1629–1682. https://doi.org/10.1111/jofi.12198

Gow, I. D., Ormazabal, G., & Taylor, D. J. (2010). Correcting for cross-sectional and time-series dependence in accounting research. *The Accounting Review*, *85*(2), 483–512. https://doi.org/10.2308/accr.2010.85.2.483

Ha, Y. J. (2021). Attention green aliens? Activities of multinational enterprises in host countries and eco-innovation diffusion. *Journal of Business Research*, *123*, 32–43. https://doi.org/10.1016/j.jbusres.2020.09.038

Hainmueller, J., & Xu, Y. (2013). ebalance: A Stata package for entropy balancing. *Journal of Statistical Software*, *54*(7), 1–18. https://doi.org/10.18637/jss.v054.i07

He, G., Fan, M., & Zhou, M. (2016). The effect of air pollution on mortality in China: Evidence from the 2008 Beijing Olympic Games. *Journal of Environmental Economics and Management*, *79*, 18–39. https://doi.org/10.1016/j.jeem.2016.04.004

He, K., Chen, W., & Zhang, L. (2021). Senior management's academic experience and corporate green innovation. *Technological Forecasting and Social Change*, *166*, 120664. https://doi.org/10.1016/j.techfore.2021.120664

Hillman, A. J., & Dalziel, T. (2003). Boards of directors and firm performance: Integrating agency and resource dependence perspectives. *Academy of Management Review*, *28*(3), 383–396. https://doi.org/10.5465/amr.2003.10196729

Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, *98*, 105134. https://doi.org/10.1016/j.eneco.2021.105134

Huang, H., Lee, E., Lyu, C., & Zhu, Z. (2016). The effect of accounting academics in the boardroom on the value relevance of financial reporting information. *International Review of Financial Analysis*, *45*, 18–30. https://doi.org/10.1016/j.irfa.2016.02.003

Huang, R. D., & Shiu, C. Y. (2009). Local effects of foreign ownership in an emerging financial market: Evidence from qualified foreign institutional investors in Taiwan. *Financial Management*, *38*(3), 567–602. https://doi.org/10.1111/j.1755-053X.2009.01048.x

Huang, W., & Teklay, B. (2021). Business professors in the boardroom: Can they walk-the-talk? *Finance Research Letters*, *39*, 101590. https://doi.org/10.1016/j.frl.2020.101590

Huang, W., & Zhu, T. (2015). Foreign institutional investors and corporate governance in emerging markets: Evidence of a split-share structure reform in China. *Journal of Corporate Finance*, *32*, 312–326. https://doi.org/10.1016/j.jcorpfin.2014.10.013

Huang, Z., Liao, G., & Li, Z. (2019). Loaning scale and government subsidy for promoting green innovation. *Technological Forecasting and Social Change*, *144*, 148–156. https://doi.org/10.1016/j.techfore.2019.04.023

Javed, M., Wang, F., Usman, M., Gull, A. A., & Zaman, Q. U. (2023). Female CEOs and green innovation. *Journal of Business Research*, *157*, 113515. https://doi.org/10.1016/j.jbusres.2022.113515

Jeon, J. Q., & Ryoo, J. (2013). How do foreign investors affect corporate policy?: Evidence from Korea. *International Review of Economics and Finance*, *25*, 52–65. https://doi.org/10.1016/j.iref.2012.05.001

Jiang, B., & Murphy, P. J. (2007). Do business school professors make good executive managers? *Academy of Management Perspectives*, *21*(3), 29–50. https://doi.org/10.5465/amp.2007.26421237

Jiang, F., & Kim, K. A. (2015). Corporate governance in China: A modern perspective. *Journal of Corporate Finance*, *32*, 190–216. https://doi.org/10.1016/j.jcorpfin.2014.10.010

Jiang, F., & Kim, K. A. (2020). Corporate governance in China: A survey. *Review of Finance*, *24*(4), 733–772. https://doi.org/10.1093/rof/rfaa012

Jin, H. M., Su, Z. Q., Wang, L., & Xiao, Z. (2022). Do academic independent directors matter? Evidence from stock price crash risk. *Journal of Business Research*, *144*, 1129–1148. https://doi.org/10.1016/j.jbusres.2022.02.054

Kazemi, M. Z., Elamer, A. A., Theodosopoulos, G., & Khatib, S. F. A. (2023). Reinvigorating research on sustainability reporting in the construction industry: A systematic review and future research agenda. *Journal of Business Research*, *167*, 114145. https://doi.org/10.1016/J.JBUSRES.2023.114145

Kennedy, P. (2008). *A guide to Econometrics*. John Wiley & Sons.

Khatib, S. F. A., Abdullah, D. F., Elamer, A. A., & Abueid, R. (2021). Nudging toward diversity in the boardroom: A systematic literature review of board diversity of financial institutions. *Business Strategy and the Environment*, *30*(2), 985–1002. https://doi.org/10.1002/bse.2665

Kim, I., Pantzalis, C., & Zhang, Z. (2021). Multinationality and the value of green innovation. *Journal of Corporate Finance*, *69*, 101996. https://doi.org/10.1016/j.jcorpfin.2021.101996

Kunapatarawong, R., & Martínez-Ros, E. (2016). Towards green growth: How does green innovation affect employment? *Research Policy*, *45*(6), 1218–1232. https://doi.org/10.1016/j.respol.2016.03.013

Li, J., Lian, G., & Xu, A. (2023). How do ESG affect the spillover of green innovation among peer firms? Mechanism discussion and performance study. *Journal of Business Research*, *158*, 113648. https://doi.org/10.1016/j.jbusres.2023.113648

Liu, T., Abdelbaky, A., Elamer, A. A., & Elmahgoub, M. (2023). Real earnings management and ESG disclosure in emerging markets: The moderating effect of managerial ownership from a social norm perspective. *Heliyon*, *9*(12), e22832. https://doi.org/10.1016/J.HELIYON.2023.E22832

Liu, Y. (2020). The comparative and interactive effects of political, academic and financial directors. *International Review of Economics and Finance*, *70*, 546–565. https://doi.org/10.1016/j.iref.2020.08.003

Luong, H., Moshirian, F., Nguyen, L., Tian, X., & Zhang, B. (2017). How do foreign institutional investors enhance firm innovation? *Journal of Financial and Quantitative Analysis*, *52*(4), 1449–1490. https://doi.org/10.1017/S0022109017000497

Mahran, K., & Elamer, A. A. (2023). Chief executive officer (CEO) and corporate environmental sustainability: A systematic literature review and avenues for future research. *Business Strategy and the Environment*. https://doi.org/10.1002/BSE.3577

McGuinness, P. B., Vieito, J. P., & Wang, M. (2017). CSR performance in China: The role of board gender and foreign ownership. *Journal of Corporate Finance*, *42*, 72–99. https://doi.org/10.1016/j.jcorpfin.2016.11.001

Nadeem, M., Bahadar, S., Gull, A. A., & Iqbal, U. (2020). Are women eco-friendly? Board gender diversity and environmental innovation. *Business Strategy and the Environment*, *29*(8), 3146–3161. https://doi.org/10.1002/bse.2563

O'Connell, D. M. (1998). From the universities to the marketplace: The business ethics journey. *Journal of Business Ethics*, *17*(15), 1617–1622. https://doi.org/10.1023/A:1006019519031

Pang, J., Zhang, X., & Zhou, X. (2020). From classroom to boardroom: The value of academic independent directors in China. *Pacific-Basin Finance Journal*, *62*, 101319. https://doi.org/10.1016/j.pacfin.2020.101319

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. Harper & Row.

Quan, X., Ke, Y., Qian, Y., & Zhang, Y. (2023). CEO foreign experience and green innovation: Evidence from China. *Journal of Business Ethics*, *182*, 535–557. https://doi.org/10.1007/s10551-021-04977-z

Selmey, M. G., & Elamer, A. A. (2023). Economic policy uncertainty, renewable energy and environmental degradation: Evidence from Egypt. *Environmental Science and Pollution Research*, *30*(20), 58603–58617. https://doi.org/10.1007/S11356-023-26426-2/FIGURES/9

Srouji, A. F., Hamdallah, M. E., Al-Hamadeen, R., Al-Okaily, M., & Elamer, A. A. (2023). The impact of green innovation on sustainability and financial performance: Evidence from the Jordanian financial sector. *Business Strategy & Development*, *6*, 1037–1052. https://doi.org/10.1002/BSD2.296

Tang, M., Walsh, G., Lerner, D., Fitza, M. A., & Li, Q. (2018). Green innovation, managerial concern and firm performance: An empirical study. *Business Strategy and the Environment*, *27*(1), 39–51. https://doi.org/10.1002/bse.1981

Thompson, S. B. (2011). Simple formulas for standard errors that cluster by both firm and time. *Journal of Financial Economics*, *99*(1), 1–10. https://doi.org/10.1016/j.jfineco.2010.08.016

Tierney, W. G. (1997). Organizational socialization in higher education. *The Journal of Higher Education*, *68*(1), 1–16. https://doi.org/10.2307/2959934

Ullah, F., Jiang, P., Elamer, A. A., & Owusu, A. (2022). Environmental performance and corporate innovation in China: The moderating impact of firm ownership. *Technological Forecasting and Social Change*, *184*, 121990. https://doi.org/10.1016/j.techfore.2022.121990

Ullah, F., Jiang, P., Mu, W., & Elamer, A. A. (2023). Rookie directors and corporate innovation: Evidence from Chinese listed firms. *Applied Economics Letters*, 1–4. https://doi.org/10.1080/13504851.2023.2209308

Usman, M., Nwachukwu, J., Ezeani, E., Salem, R. I. A., Bilal, B, & Kwabi, F. O. (2023). Audit quality and classification shifting: Evidence from UK and Germany. *Journal of Applied Accounting Research*, *ahead-of-print* (ahead-of-print). https://doi.org/10.1108/JAAR-11-2022-0309/FULL/PDF

Vasileiou, E., Georgantzis, N., Attanasi, G., & Llerena, P. (2022). Green innovation and financial performance: A study on Italian firms. *Research Policy*, *51*(6), 104530. https://doi.org/10.1016/j.respol.2022.104530

Wang, A. (2020). Professors on boards and corporate innovation in China. *Applied Economics*, *52*(41), 4474–4498. https://doi.org/10.1080/00036846.2020.1735623

Wen, W., Cui, H., & Ke, Y. (2020). Directors with foreign experience and corporate tax avoidance. *Journal of Corporate Finance*, *62*, 101624. https://doi.org/10.1016/j.jcorpfin.2020.101624

White, J. T., Woidtke, T., Black, H. A., & Schweitzer, R. L. (2014). Appointments of academic directors. *Journal of Corporate Finance*, *28*, 135–151. https://doi.org/10.1016/j.jcorpfin.2013.12.007

Xiao, H., & Wang, K. (2020). Does environmental labeling exacerbate heavily polluting firms' financial constraints? Evidence from China. *China Journal of Accounting Research*, *13*(2), 147–174. https://doi.org/10.1016/j.cjar.2020.05.001

Xu, J., Zeng, S., Qi, S., & Cui, J. (2023). Do institutional investors facilitate corporate environmental innovation? *Energy Economics*, *117*, 106472. https://doi.org/10.1016/j.eneco.2022.106472

Yang, T., & Liu, W. (2018). Does air pollution affect public health and health inequality? Empirical evidence from China. *Journal of Cleaner Production*, *203*, 43–52. https://doi.org/10.1016/j.jclepro.2018.08.242

Yu, C. H., Wu, X., Zhang, D., Chen, S., & Zhao, J. (2021). Demand for green finance: Resolving financing constraints on green innovation in China. *Energy Policy*, *153*, 112255. https://doi.org/10.1016/j.enpol.2021.112255

Zaman, R., Atawnah, N., Haseeb, M., Nadeem, M., & Irfan, S. (2021). Does corporate eco-innovation affect stock price crash risk? *The British Accounting Review*, *53*(5), 101031. https://doi.org/10.1016/j.bar.2021.101031

Zhang, D., Rong, Z., & Ji, Q. (2019). Green innovation and firm performance: Evidence from listed companies in China. *Resources, Conservation and Recycling*, *144*, 48–55. https://doi.org/10.1016/j.resconrec.2019.01.023

How to cite this article: Ullah, F., Jiang, P., & Elamer, A. A. (2024). Revolutionizing green business: The power of academic directors in accelerating eco-innovation and sustainable transformation in China. *Business Strategy and the Environment*, *33*(6), 5051–5072. https://doi.org/10.1002/bse.3738

APPENDIX A: VARIABLE MEASUREMENT

Variables	Definition
Dependent variables	
G_Patents	The natural log of 1 plus total green patents a firm filed in year *t*.
G_Inventions	The natural log of 1 plus total green invention patents a firm filed in year *t*.
Independent variables	
Board Academic 1	The total number of academic directors scaled by the total directors in year *t*.
Board Academic 2	The natural log of 1 plus the total number of directors in year *t*.
Board Academic 3	The total number of professors having prior college and university experience scaled by the total directors in year *t*.
Control variables	
Board size	The total number of directors in year *t*.
Independence	The total number of independent directors divided by the total number of directors in year *t*.
Female directors	The total number of female directors divided by total directors in year *t*.
CEO age	The natural log of CEO total age.
CEO female	A binary variable equals "1" if the CEO of a firm is female in year *t* and "0" if vice versa.
CEO duality	A binary variable equals "1" if the CEO is also the board chairman of a firm in year *t* and '0' otherwise.
Institutions	The total number of shares held by institutional investors divided by the total number of shares outstanding in year *t*.
Top one	The total number of shares held by the largest shareholder divided by the total number of shares outstanding in year *t*.
Leverage	The ratio of total debt to total assets in year *t*.
ROA	The earnings before interest and taxes by total assets in year *t*.
M/B	Market to book ratio in year *t*.
Size	Natural logarithm of a firm's total assets in year *t*.
Moderating variables	
High pollution	A binary variable equals "1" if a firm operates in polluting industries and "0" otherwise.
QFII	A binary variable equals "1" if QFIIs hold the shares of a firm in year *t* and "0" otherwise.