Economics

Top Executives' Overseas Background on Corporate Green Innovation Output: The Mediating Role of Risk Preference

--Manuscript Draft--

Manuscript Number:	ECONJOURNAL-D-24-00084
Full Title:	Top Executives' Overseas Background on Corporate Green Innovation Output: The Mediating Role of Risk Preference
Article Type:	Research Article
Keywords:	Corporate Management; Top Executives; Overseas Background; Risk Preference; Green innovation
Manuscript Region of Origin:	CHINA
Abstract:	This study employs balanced panel data encompassing Shanghai and Shenzhen A-share listed companies in China spanning the period from 2014 to 2021 as a research dataset. Employing a mixed OLS regression model and Bootstrap methods, for the purpose of investigating the influence mechanism of the overseas background and risk preference tendencies of top executives on the corporate green innovation output. The empirical findings demonstrate that the overseas background of the firm's top executives has a substantial influence on corporate green innovation, risk preference mediates the relationship between the top executives' overseas background and corporate green innovation. Additionally, the educational background of top executives is identified as a moderating element in this mechanism. Moreover, a distinctive inverted U-shaped curve characterizes the relationship between the risk preference of top executives and the level of corporate green innovation output. Thus, the conclusions drawn from this research furnish a pragmatic foundation for refining the process of selecting and nurturing high-level talents within local firms.
Manuscript Classifications:	7.6.3: Financing Policy • Financial Risk and Risk Management • Capital and Ownership Structure • Value of Firms • Goodwill; 15.3: Innovation • Research and Development • Technological Change • Intellectual Property Rights; 15.3.3: Management of Technological Innovation and R&D

Top Executives' Overseas Background on Corporate Green Innovation Output: The Mediating Role of Risk Preference

Luansong Cui, Jing Zhao, Lijuan Zhao*, Pan Hu*
College of Economics and Management, Northeast Agricultural University, Harbin 150030, China
*Email of Corresponding Author: zhaolijuan@neau.edu.cn (Lijuan Zhao), hupan16@163.com (Pan Hu)

Abstract: This study employs balanced panel data encompassing Shanghai and Shenzhen A-share listed companies in China spanning the period from 2014 to 2021 as a research dataset. Employing a mixed OLS regression model and Bootstrap methods, for the purpose of investigating the influence mechanism of the overseas background and risk preference tendencies of top executives on the corporate green innovation output. The empirical findings demonstrate that the overseas background of the firm's top executives has a substantial influence on corporate green innovation, risk preference mediates the relationship between the top executives' overseas background and corporate green innovation. Additionally, the educational background of top executives is identified as a moderating element in this mechanism. Moreover, a distinctive inverted U-shaped curve characterizes the relationship between the risk preference of top executives and the level of corporate green innovation output. Thus, the conclusions drawn from this research furnish a pragmatic foundation for refining the process of selecting and nurturing high-level talents within local firms.
Keywords: Corporate Management; Top Executives; Overseas Background; Risk Preference; Green innovation

1. Introduction

There has been a global intensification of focus on economic and environmental sustainability in response to growing social and environmental apprehensions. China, being the largest developing nation globally, is contending with substantial environmental challenges and resource limitations. Accordingly, Chinese listed companies, particularly industrial firms, are attracting public scrutiny and are prompted to implement "green" innovations. Besides, corporate governance plays a crucial role as the primary input component in driving green innovation, ultimately ascertaining its level and quality (Amore and Bennedsen, 2016; Wan et al., 2022; Xia et al., 2022), and the top management team plays a vital role in corporate governance (Cho et al., 2016; Chen et al., 2015; Liu et al., 2021a). Moreover, numerous studies have illustrated that top executives possess the following: decision-making ability, management skills, market experience, employment ability, technology foresight, as well as innovation capability (Chen et al., 2015; Dai and Liu, 2009; Lin et al., 2011). Generally, top executives who possess overseas experience exhibit proficiency in advanced technology, and possess exceptional psychological capital. Furthermore, they manifest an enhanced degree of innovation and foresight. Additionally, they demonstrate an

elevated level of innovation and foresight (Cho et al., 2016; Hao et al., 2019; Zhang and Ye, 2021a). Hence, the overseas background of top executives will impact their decision-making capabilities and willingness to confront risks, subsequently shaping the green innovation endeavors of firms.

China strategically engages in the attraction and recruitment of international talents as a focused approach to bolster its endeavors in fostering innovative development. In recent years, there has been a remarkable increase in the return of overseas talent to China, which can be partly ascribed to the influence of the talent introduction policy. In accordance with the "Survey Report on Employment and Entrepreneurship of Chinese Returnees in 2022", the number of returnees returning to seek employment has experienced a substantial rise since 2022, and the number of fresh overseas students returning to work in 2022 has attained a pinnacle, increasing by 8.6% year-over-year. Among them, more than 40% of overseas returnees' salaries meet or surpass expectations, which is more optimistic than in 2021, and according to a statistical survey, approximately 70% of overseas returnees believe overseas study experience is beneficial to their careers. Furthermore, the repatriation of highly skilled individuals from abroad will by leveraging their distinctive capabilities, individuals and entities can contribute to the progress of green innovation within Chinese firms, thereby fostering high-quality economic development and serving the nation. Moreover, there is an increasing tendency among corporations to actively pursue individuals with overseas backgrounds for recruitment into managerial positions. Hence, within this particular framework, it holds substantial practical importance to examine the influence and process of top executives' overseas background on firm green innovation.

In the current realm of research, numerous scholars have undertaken discussions concerning the influence of top executives' characteristics on corporate green innovation. Nevertheless, it is essential to recognize that some limitations and deficiencies persist within these existing studies. In the first place, only a limited number of studies examine the impact of top executives' overseas background on corporate green innovation and they ignore the mediating effect of the top executives' risk preference and the pertinent moderating factors between them (Hao et al., 2019; Quan et al., 2023). Secondly, the existing studies merely take the linear relationship between the top executives' risk preference and the firm innovation into consideration (Farag and Mallin, 2018; Giaccone and Magnusson, 2022; Zhang and Ye, 2021a, 2021b), while there are no studies considered the linear and nonlinear relationship between the top executives' risk preference as well as the corporate green innovation. Thirdly, the extant studies failed to consider the correlation between the number of green patent citations and the overseas background of top executives.

Consequently, this paper concentrates on the influence mechanism of corporate green innovation and the effect of the top executive's overseas background on corporate green innovation to enrich the related research fields. On this basis, the paper is the first study to examine the mediating effect of the top executives' risk preference and forms a complete path of the top executives overseas background, risk preference, as well as corporate green innovation. Subsequently, the moderating effect of top executives' educational background is assessed, thereby augmenting the entire influence

mechanism. This study likewise discovered an inverse U-shaped relationship between the risk preference of top executives and corporate green innovation, which can be employed as a guide to assist corporates in controlling the risk preference tendency more appropriately. Moreover, this paper has discovered a substantial correlation between the top executives' overseas backgrounds and the number of green patent citations obtained by firms, which indicates that enhancing the presence of executives with overseas backgrounds can potentially enhance the quality of green innovation within businesses. Our analysis is substantiated by data obtained from Shanghai and Shenzhen A-share listed firms spanning the years 2014 to 2021. In this way, we aim to enrich the growing literature on corporate green innovation by providing evidence on top executives' overseas backgrounds that supplement previous studies on corporate green innovation. It will also assist us in better comprehending the functional role of top executives and offer both theoretical support and practical guidance for Chinese listed firms' green innovation strategies.

The remainder of this paper proceeds as follows. Section 2 reviews the theoretical background, section 3 puts forward the hypothesis, section 4 describes the sample selection, defines the variables, and introduces the empirical model. Subsequently, section 5 reports the empirical results and discussion. Finally, section 6 presents the conclusions of this paper.

2. Literature Review

2.1 Returnee top executives

In general, the top management team is considered the primary decision-making body within the organization. Distinct divisions of the definition's extent may produce inconsistent results when evaluating the responsibilities of the top management team in the enterprise. Hence, prior to conducting appropriate studies, the scope of the top management team should be defined. In the context of this paper, the top management team is specifically defined as the pertinent members disclosed in the annual report of a listed company, including the general manager, deputy general manager, chief executive officer, chief financial officer, secretary of the board of directors, and other members participating in the company's major decisions. Besides, concerning the definition of overseas background, academic opinions lack uniformity or consistency. Some foreign scholars utilize terms comparable to "international experience" and "international exposure." On the condition that researching the relationship between top executives' overseas experience and the formation of international alliances, some scholars determined overseas background as having a foreign nationality and studying or working abroad (Lee and Park, 2008). Nevertheless, when analyzing the financial implications of top executives' overseas backgrounds, the majority of Chinese scholars defined the overseas background as having gained work experience or received education in regions and countries beyond mainland China (Hao et al., 2019; Liu et al., 2021a; Yuan and Wen, 2018). In consideration of research needs and data availability, as well as the substantial institutional distinctions between Hong Kong, Macao, Taiwan, and mainland China, in this paper, top executives with professional or educational experience in regions or countries outside mainland China are classified as possessing

an overseas background.

Corporate strategy is developed by the top management team. Furthermore, the growth environment, career experience, and educational background of the top management team have an essential impact on enterprise strategy development. Ever since Hambrick introduced the "upper echelons perspective" theory, scholarly research into the correlation between the characteristics of top executives and business strategy, actions, and performance has gained considerable prominence. According to the "upper echelons perspective" theory, the personal characteristics of top executives, including gender, age, cognitive ability, values, and special experience, will impact their behavioral patterns and cognitive processes. This, in turn, is anticipated to shape their decision-making and implementation of business strategies, ultimately manifesting in the overall performance and outcomes of the businesses they lead. Moreover, based on the resource-based theory, an enterprise can maintain its competitive advantage due to the fact that it owns scarce and unique resources (Wernerfelt, 1984). In recent years, as a growing amount of overseas expertise has returned to China and engaged firm's top management teams, scholars have redirected their research focus toward the overseas background of top executives. Moreover, returnee executives, whether they studied or worked abroad, frequently possess advanced professional technical knowledge and management experience. Concentrating their research on the chief executive officer (CEO) of an enterprise, some scholars emphasize that, as the leader of the top executives, the CEO occupies a pivotal role in the business decisions of an enterprise, wielding substantial influence. There is ample evidence that overseas experience offers CEOs more advanced knowledge of technology, innovative business concepts, as well as extensive international social networks than their domestic counterparts, empowering them to recognize and benefit from business opportunities despite fluctuations in the economy (Dai and Liu, 2009). Additionally, the presence of CEO returnees enhances the innovation performance of enterprises (Liu et al., 2010). Besides that, CEOs with strong political connections assume a more substantial role in fostering green innovation (Huang et al., 2021).

Another majority of scholars who emphasize their research on returnee directors found that performance increases following firms hire directors with international experience (Giannetti et al., 2015). Furthermore, directors who gain international experience in countries with higher standards of management practice, corporate governance, and intellectual property rights protection exert a more pronounced influence on innovative corporate activities (Tang et al., 2021). Moreover, the positive effect of directors' foreign experience on firm innovation is stronger on the condition that foreign experience is gained in highly innovative countries (Xiang and Yi, 2022). Nonetheless, the top executives and director teams are not aligned, with merely a portion of individuals serving as both directors and executives. Only a limited number of scholars direct their attention to top executives. Except for that, Yuan and Wen analyzed the impact of managerial foreign experience on firm innovation. Meanwhile, top executives with international exposure are critical to firms' international alliance formation (Lee and Park, 2008). Likewise, the foreign experience of top executives could mitigate the risk of financial distress (Liu et al., 2021a). Additionally, returnee

executives tend to achieve sustainable development through green innovation (Hao et al., 2019). Consequently, a review of the existing literature reveals a scarcity of studies exploring the influence of the top executives' overseas background on business, and more research is required on this topic.

2.2 Corporate green innovation

The Organization for Economic Cooperation and Development (OECD) defines green innovation as the creation and implementation of products and services, marketing methods, production processes, organizational structures, and institutional arrangements that can enhance the environment (Wan et al., 2022). Besides, Green innovation puts a stronger emphasis on environmental preservation and sustainability than general technological innovation, preserving resources and minimizing pollution (Liu et al., 2021b; Saunila et al., 2018). At the macro level, green innovation has progressively emerged as the primary catalyst for advancing sustainable development. At the micro level, green innovation has likewise become an essential means for firms to conduct green transformation and enhance their competitive advantages (Sun et al., 2023). Likewise, the existing studies on the factors influencing green innovation can be summarized into two dimensions: external elements as well as internal management (Wan et al., 2022).

At the macro level, Liu et al. (2021b) highlight the fact that market forces may be not enough to commit to high-quality economic development, Environmental Protection Law is an effective way to promote corporate green innovation. Moreover, Xie et al. (2017) claim distinct types of environmental regulations and heterogeneous influence on green innovation. Moreover, command-and-control type environmental policy tools exerted the most substantial influence on innovation in the context of green products (Shen et al., 2020) and the implementation of a green credit policy and setting emission taxes may likewise increase the quality of the firm green innovation(Pan et al., 2023; Wang et al., 2022a). In addition to policy considerations, businesses might seek to emulate competitors' effective green practices by examining the fundamental factors contributing to their success, which can have a substantial impact on the strategic decision-making process regarding green innovation for corporations (Zhao et al., 2021).

At the micro level, Amore and Bennedsen (2016) analyze the relationship between corporate governance and firms' green innovation and find that worse-governed firms generate fewer green patents. It has also been discovered that pressure from distinct stakeholders including consumers (Chen et al., 2012), suppliers (Rehfeld et al., 2007), and competitors (Wan et al., 2022) are determinant factors for firms' green innovation decisions. Several studies investigate various factors influencing corporate green innovation, including CEO turnover (Zhang et al., 2022), CEO gender (He and Jiang, 2019), CEO hometown identity (Ren et al., 2021), executive overconfidence (Wang, 2021), executive vertical concurrent (Lv and Chen, 2023) and executive ESG cognition (Wang et al., 2022b). Nonetheless, the current body of research about the impact of executives' background traits on the green innovation of firms remains relatively restricted. Studying or working abroad are significant experiences that might shape the top executive's values and competencies, which can ultimately affect corporate green

innovation. Nonetheless, there is little research that provides direct empirical evidence of the connection or association between top executives' foreign experience and its impact on a firm's green innovation. Quan et al. (2023) merely discovered the relationship between CEO's foreign experience and corporate green innovation. Additionally, Hao et al. (2019) investigate the direct impact between returnee executives and corporate green innovation and ignore the mediating factors between them. Expanding on this evidence, our focus centers on exploring the mechanism of corporate green innovation and assessing how the overseas background of top executives influences this aspect.

3. Hypothesis

In accordance with the imprinting theory, environmental imprinting will have an enduring effect on individuals during a specific sensitive period. On the condition of studying or working abroad, top executives must navigate diverse cultural backgrounds, uncertain work environments, and high-risk challenges, as well as psychological pressure. During this critical period, the exposure of top executives to a foreign environment can imbue them with a nuanced set of cognitive abilities and skills. This, in turn, enables them to make forward-thinking and bold decisions regarding long-term green innovation.

Based on the knowledge spillover effect, acquiring knowledge and experience from outside the organization is an essential method for firms to increase their innovation efficiency. Besides, the top management team with extensive overseas background possesses explicit knowledge acquired through language, books, databases, etc., as well as implicit knowledge acquired through long-term practice, which can furnish organizations with an extensive reservoir of knowledge and valuable expertise derived from a global standpoint, and produce a significant knowledge spillover effect. Consequently, top executives with overseas backgrounds can effectively enhance the green innovation efficiency of local enterprises.

The "upper echelons perspective" theory claims that the top executives of an enterprise cannot completely comprehend the environment's complexity, and yet instead observe and make decisions selectively. Throughout this process, the manager's values and cognitive framework dictate their mode of reasoning, observational outlook, and decision-making. Top managers' demographic characteristics and prior experience will affect their cognitive ability, logic of thought, and value orientation, which will subsequently determine the strategic decision-making and innovation activities of businesses. As an illustration, the top management team's international background will affect the firm's innovation decisions and activities, with both foreign study experience and foreign work experience having significant impacts on firm innovation (Yuan and Wen, 2018). Moreover, CEO foreign experience is a significant factor for corporate green innovation in emerging markets (Quan et al., 2023). Following returnees joining the top management team, the heterogeneity between returnees and local top executives impacts the corporate green innovation (Hao et al., 2019). Drawing on the preceding perspectives, this paper puts forward Hypothesis 1.

Hypothesis 1: The overseas background of top executives promotes corporate

green innovation.

Behavioral finance theory states that managers are influenced by personal psychological factors, social environmental factors, and various uncertainties when making decisions, which leads to their behavior patterns and attitude toward risk deviating from the optimal model established by economics. In accordance with behavioral finance theory, diverse executive teams are prone to make disparate decisions when faced with analogous circumstances. The key concept of behavioral finance theory is expectancy theory, which emphasizes that the majority of managers are not entirely rational and frequently expose themselves to greater risks in pursuit of greater returns. Moreover, as the decision-maker for corporate green innovation activities, the top executives will be impacted by subjective factors including risk preference, contributing to variations in the output of enterprise innovation.

Consequently, according to behavioral finance theory, in addition to objective factors including the demographic characteristics and prior experience of the top executives, subjective factors including the risk preference of the top management team can also impact corporate innovation activities. Enterprises guided by leaders with international expertise exhibit increased investment activities, partake in more mergers and acquisitions, maintain elevated debt-to-equity ratios, and possess a greater proportion of short-term debt (Yang and Wang, 2023). Accordingly, there is a considerable positive correlation between the international experience of top executives and their risk preferences. Additionally, numerous scholars indicated that risk-taking has a substantial positive correlation with innovation performance (Giaccone and Magnusson, 2022; Zhang and Ye, 2021b). On the basis of the preceding discussion, we posit the subsequent hypotheses:

Hypothesis 2: The richer the overseas background of the top management team, the stronger the risk preference tendency.

Hypothesis 3: Risk preference has a mediating effect between the top executives' overseas background and the corporate green innovation output.

On the condition that examining the mechanism of the effect of the overseas background of the executive team on the innovation output of businesses, previous scholars analyzed the mediating variables, including the risk preference of the executive team as well as considered additional personal attributes of the senior executives. Regarding individual CEO characteristics, some researchers stated that younger CEOs, those with shorter tenures, and those with advanced degrees are more inclined to contemplate and undertake decisions associated with higher risk (Farag and Mallin, 2018). In addition, the CEO's education level, professional background, and political connections are positively associated with the enterprise's innovation efforts (Lin et al., 2011). Concerning executive teams, returnee executives have a higher level of education than local executives in general, and their education exerts a noteworthy positive impact on various facets of venture performance (Li et al., 2012). In conclusion, among the samples of executive teams with distinct educational backgrounds, the overseas educational background of executive teams has diverse influences on the green innovation output of businesses. Accordingly, this paper proposes hypothesis 4.

Hypothesis 4: The lower the average education level of the top executives, the

stronger the promoting effect of top executives' overseas background on their risk preference level.

Existing literature typically employs the number of patent citations to measure the quality of the innovation output (Bhattacharya et al., 2017; Hirshleifer et al., 2012; Rahko, 2016). Green patents with high technical levels, significant economic importance, and great importance have high citations (Wang et al., 2022a; Zhang et al., 2022). Moreover, Quan et al. (2023) CEOs with international experience exhibit a higher propensity for green innovations and achieve a superior level of quality. Consequently, this paper proposes hypothesis 5.

Hypothesis 5: The overseas background of top executives promotes the quality of the corporate green innovation output.

Previous studies determined that corporate risk-taking plays a role in mediating the impact of corporate strategy on innovation performance (Li et al., 2021). Previous studies also discovered an inverted U-shaped relationship between executives' risk preferences and firm Innovation (Zhang and Ye, 2021a). Moreover, on the condition that there are more risk-averse members in the top management team, the firm tends to forego input projects with extra income and shareholder benefits, and it also reduces its innovation activities, i.e., It is hesitant to allocate excessive resources to R&D and the exploration of new markets (Zhang and Ye, 2021b). Relevant literature has enriched the mechanism of the impact of enterprise risk awareness on innovation activities. Hence, enhancing the comprehensiveness and persuasiveness of the conclusion. Building upon the preceding perspectives, we put forth Hypothesis 6.

Hypothesis 6: There is an inverted U-shaped relationship between the top executives' risk preference and the corporate green innovation output. Risk-averse and risk-seeking executive teams are less conducive to corporate green innovation output level than top management teams with moderate risk preference.

4. Methodology

4.1 Data collection

We chose all A-share listed firms in the Shanghai and Shenzhen stock exchanges from 2014 to 2021 as the initial sample. Besides, data for green patent applications and citations are gathered from the Chinese Research Data Service (CNRDS) platform. Additional data is gathered from the China Securities Market and Accounting Research (CSMAR) database. Furthermore, we excluded observations with missing data, resulting in a final dataset comprising 19,976 firm-year observations corresponding to 2,497 listed firms. The continuous variables in this paper are subjected to a 1% level Winsorize. Considering the potential lag effect of green innovation, the empirical regressions in this paper consider a one-year lag (Gao et al., 2022).

4.2 Measurement of variables

4.2.1 Dependent variables

Following prior studies, we employ the number of green patent applications to measure the green innovation output (Amore and Bennedsen, 2016; Lv and Chen, 2023; Quan et al., 2023), we utilize the natural logarithm of one plus the total number of independent & joint green patent applications filed by a firm in a year of the company (Patent). Additionally, we take advantage of the number of green patent citations to

represent the quality of corporate green innovation output (Patentquote).

4.2.2 Independent variables

This paper primarily centers on the top management team of publicly listed firms, assessing the international background of the team by gauging the proportion of executives with overseas experience relative to the total number of executives (Hao et al., 2019). Moreover, the overseas background of the top management team is divided into three categories: overseas working experience (Overseas W), overseas study experience (Overseas E), and double overseas experience (Overseas B), each of these dimensions is assessed by determining the proportion of top management team members possessing the respective experience in relation to the total number of individuals (Yuan and Wen, 2018).

4.2.3 Mediating variable

This study's mediator variable is the top executives' risk preference index (RPI). The risk preference of top managers is their attitude toward risk. This relatively stable subjective characteristic exerts a substantial influence on decisions related to risk management. The utility curve classifies risk preference into three distinct categories: risk neutral, risk aversion, as well as risk-seeking. This paper employs the ratio of enterprise risk assets to total assets to assess the risk preference of the top management team (Zhang and Ye, 2021a, 2021b). Moreover, the greater the proportion of risk assets in a company, the higher the likelihood that the top executive team will lean towards embracing risk. Additionally, the risk preference index (RPI) is subdivided for observational purposes into short-term risk preference (SRPI) and long-term risk preference (LRPI).

4.2.4 Moderating variables

In this research, the educational background of the top executives was measured by the ratio of the number of individuals with master's degrees or above to the total number of top management team members, and the moderating impact of the top management team's educational background on the links between overseas background and risk preference was examined.

4.2.5 Control variables

On the basis of existing literature (Chen et al., 2015; Hao et al., 2019; Yuan and Wen, 2018), in this study, variables were controlled from two perspectives: company characteristics and top management team characteristics, which controls firm size (Size), asset-liability ratio (Lev), firm Growth (Growth), return on assets (ROA), and firm establishment years (Fage) regarding company characteristics. Moreover, the age and tenure of the top executives are controlled by the characteristics of the top management team, and the definitions of major variables are demonstrated in Appendix 1.

4.3 Empirical models

To test the impact of the top executives overseas background on the corporate green innovation output (hypothesis 1), the subsequent OLS regression model was formulated.

$$Patent_{i,t} = \beta_0 + \beta_1 Overseas_{i,t} + \beta_2 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where i represents the listed company, t indicates the year, β_i symbolizes regression coefficients and ε signifies the error term. Besides, the dependent variable Patent is our proxy for corporate green innovation, while overseas is the independent variable, which measures the percentage of top executives with overseas backgrounds in firms.

For the purpose of assessing the impact of the top executives' overseas background on the top executives' risk preference level (hypothesis 2), this paper establishes an OLS regression model (2).

$$RPI_{i,t} = \beta_0 + \beta_1 Overseas_{i,t} + \beta_2 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (2)$$

RPI is the mediating variable that represents the top executives' risk preferences.

To assess whether the risk preference of top executives acts as a mediator in the relationship between their overseas experience and corporate green innovation output (hypothesis 3). Based on models (1) and (2), this paper establishes the OLS regression model (3).

$$Patent_{i,t} = \beta_0 + \beta_1 Overseas_{i,t} + \beta_2 RPI_{i,t} + \beta_3 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (3)$$

This study constructs an OLS regression model (4) to investigate the potential moderating effect of the educational background of top executives on the relationship between their overseas background and risk preference (hypothesis 4). If the statistical significance of the regression coefficient for the interaction term between the overseas background and educational background of the top management team is negative, it indicates that the impact of the top management team's overseas background on corporate innovation output is more pronounced in teams characterized by lower educational backgrounds.

$$\begin{aligned} RPI_{i,t} = {} & \beta_0 + \beta_1 Overseas_{i,t} + \beta_2 Education_{i,t} + \\ & \beta_3 Overseas_{i,t} \times Education_{i,t} + \beta_4 \Sigma Control_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (4)$$

This paper establishes OLS regression models (5) to test whether there is a correlation between the top executives' overseas background and the corporate green innovation quality (hypothesis 5).

$$Patentquote_{i,t} = \beta_0 + \beta_1 Overseas_{i,t} + \beta_2 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (5)$$

To test the nonlinear relationship between the top executives' risk preference and the corporate green innovation output (hypothesis 6), this paper establishes the OLS regression model (6a) (6b) (6c). If $\beta 1 > 0$ and $\beta 2 < 0$ in the model (6c), it can be proved that there is an inverted U-shaped relationship between the top executives' risk preference and the corporate green innovation output, which can serve as evidence supporting the validity of Hypothesis 6.

$$Patent_{i,t} = \beta_0 + \beta_1 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (6a)$$

$$Patent_{i,t} = \beta_0 + \beta_1 RPI + \beta_2 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (6b)$$

$$Patent_{i,t} = \beta_0 + \beta_1 RPI + \beta_2 RPI2 + \beta_3 \Sigma Control_{i,t} + \varepsilon_{i,t} \quad (6c)$$

5. Empirical Results and Discussion

5.1 Descriptive statistics

Table 1 denotes the descriptive statistical results for all continuous variables following Winsorize treatment at the 1% level. Throughout the study period, the mean number of green patent applications per year stood at 1.85, with a minimum of 0, a maximum of 5.45, and a standard deviation of the total number of patent applications at 1.2. Furthermore, the mean annual number of citations for green patents (Patentquote) is 2.39, with a minimum of 0, a maximum of 6.36, and a standard deviation of 1.62. Regarding the Overseas background of the firm's top management team, the average number of top executives with an overseas background accounts for merely 0.8% of the firm's top management team. Particularly, 3.8% of the average top executives have overseas working experience (Overseas W). Moreover, 0.9% of top executives have a background in overseas study (Overseas E), whereas 2.4% of top executives have a dual background in work and study (Overseas B). In some enterprises, the number of top executives with overseas backgrounds exceeds one-third, whereas a substantial number of businesses lack top executives with overseas backgrounds, and the diversity of overseas experience among top executives is unequal. Additionally, the average level of risk preference (RPI) among the top management teams is 0.114, demonstrating that the company's risk assets account for approximately 11.4% of total assets. Ultimately, the average number of executives with a master's degree or higher was 63.6%, this suggests that the average educational attainment of top executives is relatively elevated.

Table 1. Descriptive statistics of the variables.

Variable	N	Mean	SD	Min	Max
Patent	19841.000	1.852	1.197	0.000	5.446
Patent quote	19841.000	2.391	1.620	0.000	6.363
Overseas	19976.000	0.058	0.114	0.000	0.500
Overseas W	19976.000	0.038	0.094	0.000	0.500
Overseas E	19976.000	0.009	0.040	0.000	0.250
Overseas B	19976.000	0.024	0.061	0.000	0.333
RPI	19976.000	0.114	0.086	0.002	0.406
Education	18831.000	0.636	0.275	0.125	1.000
Size	19976.000	22.443	1.333	19.540	26.382
Lev	19925.000	0.452	0.211	0.062	0.971
Growth	16322.000	-0.765	9.427	-65.517	30.406
ROA	19796.000	0.023	0.239	-1.661	0.347
Fage	19925.000	2.937	0.305	1.946	3.497
Age	19970.000	3.862	0.081	3.624	4.025
Tenure	16949.000	1.358	0.555	0.000	2.451

Note: This table reports descriptive statistics for the main variables of the article. The sample period is from 2014 to 2021, continuous variables in this paper are subjected to a 1% level Winsorize, and all variables are defined in Table 1.

5.2 Hypothesis test

5.2.1 Top executives' overseas background, risk preference, and corporate green innovation

The regression results for model (1) are illustrated in column (1) of Table 2. Based on the results from the regression analysis depicted in column (1), it is observed that the regression coefficient β1 associated with the Overseas background of the top management team exhibits a statistically substantial positive relationship at the 1% significance level, which suggests that an increase in the corporate green innovation output is associated with the richness of the top executives' overseas backgrounds. Consequently, hypothesis 1 has been confirmed. Moreover, based on the examination of firm level, it is evident that the coefficient of firm size (Size) exhibits a statistically significant positive relationship at a significance level of 1%. Larger firms possess greater capacity to engage in innovation activities, leading to elevated levels of innovation productivity. The regression coefficient for the company's asset-liability ratio (Lev) exhibits a statistically substantial negative relationship at a significance level of 1%, which illustrates that there is a negative association between the asset-liability ratio and green innovation output, illustrating that lower levels of leverage are associated with higher levels of green innovation. Moreover, the coefficient of firm age (Fage) demonstrates a notable adverse correlation at a 5% significance level. This finding suggests that firms with a longer history of establishment are less inclined to participate in the development of green innovations.

Table 2. Model (1)-(5) empirical test results.

	(1) Model 1 Patent	(2) Model 2 RPI	(3) Model 3 Patent	(4) Model 4 RPI	(5) Model 5 Patent quote
Overseas	1.516***	0.210***	1.466***	0.269***	1.846***
	(12.042)	(15.507)	(11.409)	(9.190)	(11.339)
Size	0.274***	-0.008***	0.276***	-0.009***	0.386***
	(10.318)	(-3.001)	(10.359)	(-3.058)	(10.632)
Lev	-0.314***	0.015	-0.318***	0.018*	-0.439***
	(-3.465)	(1.527)	(-3.504)	(1.780)	(-3.580)
Growth	-0.001	0.000	-0.001	0.000	-0.001
	(-0.784)	(0.516)	(-0.795)	(0.258)	(-0.851)
ROA	0.088	-0.010	0.091	-0.010	0.131
	(1.162)	(-1.392)	(1.194)	(-1.331)	(1.267)
Fage	-0.430**	0.005	-0.431**	0.003	-0.351
	(-2.188)	(0.289)	(-2.195)	(0.183)	(-1.330)
Age	0.259	-0.008	0.261	-0.009	0.294
	(1.579)	(-0.484)	(1.591)	(-0.534)	(1.286)
Tenure	-0.006	0.000	-0.006	0.000	-0.010
	(-0.474)	(0.398)	(-0.484)	(0.422)	(-0.562)
RPI			0.238*		
			(1.815)		
Education				0.012**	

				(2.412)	
OE				-0.099**	
				(-2.551)	
_cons	-3.944***	0.299***	-4.016***	0.314***	-6.228***
	(-3.904)	(2.976)	(-3.975)	(3.001)	(-4.488)
ID	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes
N	13585	13641	13585	12899	13585
R^2	0.753	0.650	0.753	0.662	0.734

Note: This table reports the OLS regression result of Model (1)-(5). The independent variable is the number of top executives with overseas backgrounds divided by the total number of top executives in the firm (Overseas). The dependent variable in Columns 1, 3 is the natural logarithm of one plus firm's all green patents, including invention, design, and utility model green patents (Patent). The dependent variable in Columns 2, 4 is the firm's risk asset divided by total asset (RPI). The dependent variable in Column 5 is the natural logarithm of one plus the number of citations of all green patents (Patent quote). RPI is the mediating variable which denotes the top executives' risk preference, education is the moderating variable. The research models were all controlled for the variables of year and industry, and the standard errors of the regression results were modified by clustering at the level of the firm. All variables are identified in Appendix 1. *, **, and *** indicate the significant level of 10%, 5%, and 1% respectively, and the standard error SE in brackets.

The regression results for model (2) are illustrated in column (2) of Table 2. Based on the regression results indicated in column (2), it is observed that the regression coefficient β1 about the overseas background of the top management team exhibits a statistically significant positive relationship at the 1% significance level, which reveals that as the top management team possesses a more extensive overseas background, they exhibit a tendency towards a higher risk preference. Consequently, hypothesis 2 is confirmed, and the regression coefficient of the control variable, firm size (Size), exhibits a statistically significant negative relationship at the 1% level. This discovery contradicts the inference made from the model (1), indicating that larger enterprises do not necessarily maintain a stable market advantage and are inclined to adopt more cautious strategies in the face of uncertain risks.

The test results for hypothesis 3 are collectively indicated in columns (1) to (3) of Table 2. Column (3) demonstrates the result of the combined influence of overseas background and risk preference (RPI) of the top executives on corporate green innovation. The regression coefficients, β1 representing overseas background, and β2 representing risk preference, both exhibit statistically significant positive values, thus confirming Hypothesis 3. Furthermore, it is observed that the regression coefficient of the top executives overseas background in the model (3) is comparatively smaller than the corresponding coefficient in model (1) (1.466<1.516). This finding further affirms the notion that the risk preference of the top management team functions as a partial mediator between the top executives' overseas background and corporate green innovation. Particularly, the overseas background of the top management team can augment the team's inclination towards risk preference, consequently boosting the corporate green innovation output.

5.2.2 Moderating effect: the educational background of the top executives

This research additionally substantiates the moderating influence of overseas

background, risk preference, and corporate green innovation. The empirical results derived from the examination of columns (4) in Table 2 offer support for the idea that the educational background of the top management team serves as a moderating factor on the observed outcomes. Specifically, the educational background of the top management team has a reverse moderating effect on the impact of its overseas background on risk preference.

Column (4) in Table 2 indicates the findings of hypothesis 4. It reveals that the regression coefficient of the interaction term (OE) between the overseas background and the educational background of the top executives is statistically significant and negative at a significance level of 5%. This outcome affirms that the educational background of the top management team exerts a counteractive moderating impact on the association between their overseas background and risk preference. The findings indicate that within a top management team characterized by a low average education level, the presence of top executives with an overseas background substantially affects the team's inclination towards risk. Particularly, the experience of studying or working overseas among top executives compensates to some degree for the top management team's lack of educational level and consequently enhances their courage to confront unfamiliar risks. As demonstrated in Figure 1, hypothesis 4 is validated.

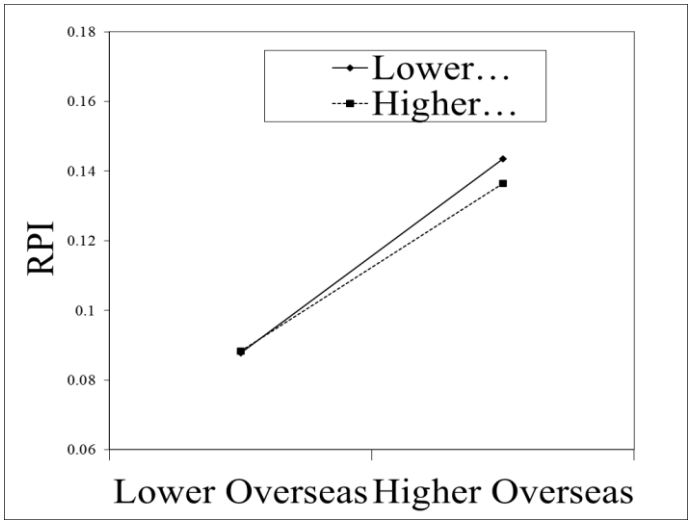

Figure 1. The moderating effect of education

5.2.3 Top executives' overseas background and corporate green innovation quality.

The findings in Column (5) of Table 2 indicate the empirical results of hypothesis 5. Based on the data presented in column (5), it is noted that the regression coefficient β1 in association with the overseas background of the top executives exhibits a statistically remarkable positive relationship at the 1% significance level, which suggests that an increase in the number of green innovation patent citations is associated with the richness of the top executives' overseas backgrounds. Thus, hypothesis 5 is verified. Moreover, the overseas background of top executives promotes the quality of the corporate green innovation output.

5.2.4 Testing the nonlinear relationship between top executives' risk preference and corporate green innovation

This study additionally investigates the non-linear relationship between top

executives' risk preference and the output of corporate green innovation. Columns (1) to (3) in Table 3 reveal the test results of models 6(a), 6(b), and 6(c), respectively. As can be observed from the regression outcomes in column (3), the primary term coefficient β1 of Top executives' risk preference (RPI) is significantly positive at 1% level, and the secondary term coefficient β2 of Top executives' risk preference is significantly negative at 1% level. Besides, the results indicate that there is an inverted U-shaped curve association between the risk preference of the top management team and the Corporate Green Innovation output (refer to Figure 2). As a result, the findings provide support for hypothesis 6, which implies that enterprises led by risk-averse and risk-seeking top management teams exhibit lower levels of innovation output on the condition when in comparison to those led by risk-neutral top management teams.

Table 3. Model (6a)-Model (6c) empirical test results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Patent	Patent	Patent	Patent	Patent	Patent
RPI		0.676***	1.247***	-2.258	0.457**	0.009
		(5.146)	(5.297)	(-0.324)	(2.397)	(0.015)
RPI2			-1.829***			
			(-2.827)			
Size	0.302***	0.305***	0.304***	0.241*	0.329***	0.409***
	(11.191)	(11.306)	(11.280)	(1.864)	(10.373)	(4.320)
Lev	-0.316***	-0.326***	-0.322***	-0.268	-0.380***	-0.051
	(-3.493)	(-3.595)	(-3.558)	(-0.894)	(-3.509)	(-0.132)
Growth	-0.001	-0.001	-0.001	0.002	-0.001	0.000
	(-1.162)	(-1.159)	(-1.132)	(0.701)	(-1.374)	(0.102)
ROA	0.103	0.109	0.108	-0.620	0.106	0.126
	(1.331)	(1.411)	(1.402)	(-1.492)	(1.119)	(0.782)
Fage	-0.404**	-0.410**	-0.408**	-1.599	-0.562**	-0.221
	(-1.994)	(-2.030)	(-2.023)	(-1.264)	(-2.494)	(-0.308)
Age	0.246	0.254	0.256	0.050	0.115	0.495
	(1.480)	(1.524)	(1.544)	(0.080)	(0.609)	(0.839)
Tenure	-0.006	-0.006	-0.006	0.050	-0.013	-0.028
	(-0.443)	(-0.472)	(-0.489)	(0.967)	(-0.916)	(-0.655)
_cons	-4.526***	-4.676***	-4.691***	0.714	-4.154***	-8.164**
	(-4.391)	(-4.541)	(-4.560)	(0.156)	(-3.524)	(-2.282)
ID	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes
N	13585	13585	13585	979	10765	1130
R^2	0.746	0.747	0.747	0.783	0.744	0.873

Note: This table reports the OLS regression result of Model (6a)-(6c). All variables are defined in Appendix 1. *, **, and *** indicate the significant level of 10%, 5%, and 1% respectively, and the standard error SE in brackets.

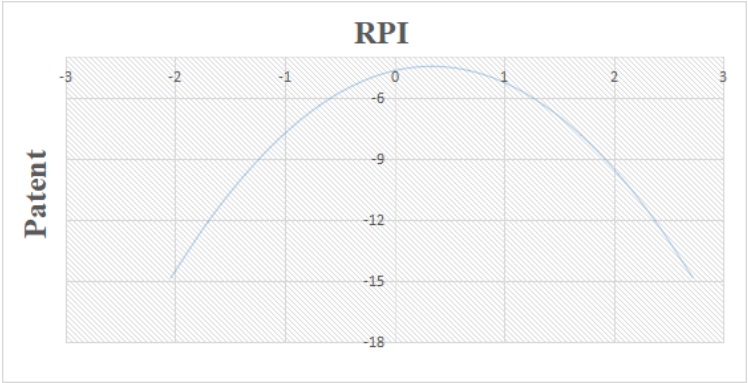

Figure 2. The U-shaped curve relationship between the risk preference of the top management team (RPI) and the corporate green innovation (Patent)

For the purpose of further verifying the inverted U-shaped relationship between the top management team's risk preference and the corporate green innovation output, this study takes the 10% quantile (RPI=0.018) and 90% quantile (RPI=0.22) of the risk preference index of the top management team as nodes. The entire sample was categorized into three groups: a risk-averse top management team (RPI≤0.018), risk-neutral top management team (0.018<RPI<0.22), and risk-loving top management team (RPI≥0.22). Moreover, the three groups of samples were substituted into model 6(b) respectively for linear regression analysis, and the results were indicated in columns (4) to (6) of Table 3. Furthermore, in the sample of risk-averse top management teams (RPI≤0.018), the regression coefficient β1 of top executives' risk preference is not statistically significant; thus, it cannot be demonstrated that top executives' risk preference affects the innovation output of the firm. In the sample of risk-neutral top management teams (0.018<RPI<0.22), the regression coefficient β1 of top executives' risk preference is significantly positive at the level of 5%, which aligns with the overall sample, revealing that the stronger the risk preference tendency of the top executives, the higher the innovation output level of the enterprise managed by the executive team. Nonetheless, in the sample of the risk-seeking top management team (RPI≥0.22), the lack of statistical significance in the regression coefficient β1 associated with the risk preference of top executives suggests that within firms led by risk-seeking top management teams, a heightened level of risk preference does not contribute significantly to the promotion of the firm's innovation output. Additionally, the research concludes that neither risk-averse nor risk-seeking executive teams are conducive to the formation of innovation output, whereas in risk-neutral executive teams (risk preference tends to constitute 10% to 90% of the overall level), as the risk preference tendency of top executives increases, so does the level of green innovation output. The conclusion once again confirms the verified mediation effect path, namely that the overseas background of the top management team can enhance the firm's green innovation output by elevating the risk preference level of the top management team.

In conclusion, extreme risk aversion or risk seeking is not conducive to the production of innovative output. Managing the risk preference level of top executives within a reasonable range, as determined by the company's leadership, is a suitable

approach to enhance innovation output.

5.3 Robust Tests

5.3.1 Mediating effect test: bootstrap method

Due to the nonlinear distribution characteristics of the top management team's risk preference as a mediator variable, the Bootstrap method was employed in this study to mitigate the estimation bias, as well as the mediating effect of the top management team's risk preference tendency between the top management team's overseas background as well as the corporate green innovation output was examined once again. Table 4 illustrates the results of a 500-sample Bootstrap test, the coefficient of direct effect is 2, and the confidence interval at the 95% level is [1.834-2.169], excluding 0, demonstrating that the direct effect of the overseas background of the top executives on corporate green innovation is significant. Once again, Hypothesis 1 has been validated. Subsequent investigations unveil that the mediator effect coefficient of the top executives' overseas background—top executives' risk preference—corporate green innovation mechanism is 2.31, with a 95% confidence interval of [2.15-2.47], excluding 0. This signifies that augmenting the top executives' risk preference tendency is a crucial mechanism for elevating the corporate green innovation output level associated with the top executives' overseas background, thus supporting Hypothesis 3.

Table 4. Bootstrap test results

	Observed coefficient	Bootstrap std. err.	z	P>z	Normal-based [95% conf. interval]	
Direct effect	2.0017***	0.0855	23.42	0.000	1.8342	2.1692
Mediating effect	2.3121***	0.0811	28.50	0.000	2.1531	2.4711

Note: This table reports the results of the mediating effect of the top management team's risk preference (RPI) between the top management team's overseas background (Overseas) and the corporate green innovation output (Patent). *, ** and *** demonstrate the significant level of 10%, 5% and 1% respectively.

5.3.2 Endogeneity test: propensity score matching (PSM) method

The PSM propensity score matching method was utilized to test the samples to strengthen the authenticity and validity of the research conclusions and mitigate the probability of endogenous issues in the empirical study, as there might be a "screening effect" in the enterprises of the top executives with an overseas background. In this study, all samples were categorized into two groups on the basis of the mean proportion of overseas executives in the top management team (0.058): the treated group (Overseas > 0.058) and the control group (Overseas < 0.058). Besides, the propensity score was estimated utilizing seven control variables, including firm Size (Size), asset-liability ratio (Lev), firm growth (Growth), return on assets (ROA), firm establishment years (Fage), top executives' age (Age), and tenure (Tenure). The nearest neighbor matching method was employed, and samples with comparable propensity scores were matched in a 1:1 ratio. To ensure that all samples from the treatment group can be

matched with samples from the control group, the study employs the sampling procedure with replacement, and the results of the balance test illustrate that the deviation of the seven matching variables is less than 5%, indicating that sample matching is effective, and 13,087 observed samples were obtained after matching. This paper utilizes matched samples for regression analysis. Table 5 (1) assesses the influence of the overseas background of the top management team on the firm's innovation output. Moreover, Table 5 (2) displays the results of an experiment examining the effect of the overseas background of the top management team on the team's risk preference. Additionally, the regression coefficient of the overseas background of top executives is substantially positive at 1% in both models, demonstrating that following eliminating the endogenous problem, the greater the overseas background of top executives, the stronger the risk preference tendency of the top management team and the greater firm's innovation output level. Consequently, hypothesis 1, hypothesis 2, and hypothesis 3 remain valid.

Table 5. Propensity score matching (PSM) test results

	(1)	(2)
	Patent	RPI
Overseas	1.359***	0.183***
	(9.903)	(13.052)
Size	0.266***	-0.016***
	(8.359)	(-4.217)
Lev	-0.284**	0.029**
	(-2.437)	(2.379)
Growth	0.001	0.000
	(0.649)	(1.489)
ROA	-0.051	-0.005
	(-0.554)	(-0.561)
Fage	-0.120	0.022
	(-0.507)	(1.026)
Age	0.224	-0.006
	(1.122)	(-0.298)
Tenure	-0.007	0.000
	(-0.467)	(0.060)
_cons	-4.464***	0.414***
	(-3.667)	(3.184)
ID	Yes	Yes
YEAR	Yes	Yes
N	13087	13143
R^2	0.794	0.725

Note: This table reports the PSM test results, all samples were divided into two categories based on the mean proportion of overseas executives in the top management team (0.058): the treated group (Overseas > 0.058) and the control group (Overseas < 0.058). *, ** and *** indicate the significant level of 10%, 5% and 1% respectively.

5.3.3 Alternative test: alternative examination method

In this study, the mediating variable is subsequently replaced with the short-term risk preference (SRPI) of the top management team, which has a more direct impact on the firm's latest innovation decision. Accordingly, the proportion of short-term risk assets instead of the proportion of long-term risk assets is employed to measure the top management team's risk preference. Model (1) was repeated to model (6), and the regression results are shown in Table 6. Moreover, the regression coefficients of the main variables in model (1) to model (3) are significantly positive at the 1% significance level, which verifies that the short-term risk preference of the top management team serves as a mediating factor between the overseas background of the top management team and the firm's innovation output, hypotheses 1 to 3 are verified. In model (4), the interaction term coefficient between the overseas background and the educational background of the top management team is substantially negative, indicating that the educational background of the executive team regulates the relationship between the overseas background of top executives and their risk preference in the opposite direction, and hypothesis 4 has been validated. In model (5), the regression coefficients of the main variables are significantly positive at the 1% significance level, which verifies hypothesis 5. Additionally, the short-term risk preference of the top management team acts as a mediator between the top executives' overseas background and the quality of the green innovation output. The regression coefficients of the primary variables in the model (6) are all significant, which verifies that there is an inverted U-shaped relationship between the top executives' short-term risk preference and the firm's innovation output level, and supporting hypothesis 6.

Table 6. Alternative test results

	(1) Patent	(2) SRPI	(3) Patent	(4) SRPI	(5) Patent quote	(6) Patent	(7) Patent	(8) Patent
Overseas	1.516***	0.246***	1.459***	0.337***	1.767***			
	(12.042)	(11.780)	(11.527)	(7.192)	(10.772)			
SRPI			0.232***		0.323***		0.437***	1.388***
			(2.826)		(2.861)		(5.297)	(9.428)
SRPI2								-2.437***
								(-7.931)
Education				0.027***				
				(3.464)				
OE				-0.153**				
				(-2.544)				
Size	0.274***	-0.004	0.275***	-0.006	0.387***	0.302***	0.302***	0.300***
	(10.318)	(-1.131)	(10.363)	(-1.552)	(10.676)	(11.191)	(11.227)	(11.292)
Lev	-0.314***	0.021	-0.319***	0.023	-0.446***	-0.316***	-0.325***	-0.323***

	(-3.465)	(1.458)	(-3.516)	(1.509)	(-3.632)	(-3.493)	(-3.583)	(-3.591)
Growth	-0.001	0.000	-0.001	0.000	-0.001	-0.001	-0.001	-0.001
	(-0.784)	(0.552)	(-0.805)	(0.484)	(-0.872)	(-1.162)	(-1.175)	(-1.191)
ROA	0.088	-0.012	0.091	-0.010	0.135	0.103	0.108	0.104
	(1.162)	(-1.088)	(1.197)	(-0.914)	(1.302)	(1.331)	(1.383)	(1.340)
Fage	-0.430**	-0.026	-0.424**	-0.030	-0.342	-0.404**	-0.395*	-0.395**
	(-2.188)	(-0.868)	(-2.156)	(-0.953)	(-1.297)	(-1.994)	(-1.951)	(-1.973)
Age	0.259	0.004	0.259	0.007	0.293	0.246	0.246	0.253
	(1.579)	(0.156)	(1.573)	(0.288)	(1.282)	(1.480)	(1.479)	(1.531)
Tenure	-0.006	0.001	-0.006	0.001	-0.010	-0.006	-0.006	-0.005
	(-0.474)	(0.622)	(-0.497)	(0.339)	(-0.585)	(-0.443)	(-0.488)	(-0.371)
_cons	-3.944***	0.324**	-4.019***	0.347**	-6.332***	-4.526***	-4.626***	-4.669***
	(-3.904)	(2.151)	(-3.979)	(2.212)	(-4.562)	(-4.391)	(-4.499)	(-4.583)
ID	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	13585	13641	13585	12899	13585	13585	13585	13585
R^2	0.753	0.622	0.753	0.631	0.734	0.746	0.747	0.749

Note: This table reports the alternative test results, the previous mediating variable RPI is replaced with the short-term risk preference (SRPI) of the top management team, and short-term risk assets instead of the proportion of long-term risk assets is employed to measure the top management team's risk preference. *, ** and *** indicate the significant level of 10%, 5% and 1% respectively.

5.4 Further study

5.4.1 Types of top executives' overseas background, risk preference, and corporate green innovation

This paper examines three categories of overseas experience among top executives: overseas working experience (Overseas W), overseas studying experience (Overseas E), and overseas both working and studying experience (Overseas B). To further investigate whether there are distinctions in the impact of distinct types of overseas backgrounds of top executives on the level of corporate green innovation output and risk preference of top executives, the aforementioned three types of variables are substituted as independent variables in Model (1) and Model (2) for regression analysis, respectively. The results of the model's regression are demonstrated in Table 7, and the results of overseas background and innovation output for three categories of top executives are displayed in columns (2) to (4), whereas the results of overseas background and risk preference for three types of top executives are displayed in columns (6) to (8). Moreover, the regression results indicate that the regression coefficients of the overseas background of the three types of top executives are all significantly positive at the 1% level, indicating that both the overseas working background of top executives and the overseas studying background of top executives exert a notable positive impact on the corporate green innovation output under their leadership and the team's risk preference tendency. Additionally, the regression coefficients for the three categories of overseas background indicators, namely dual overseas background, overseas working background, and overseas studying the

background of top executives, display a descending order in their correlation with corporate green innovation output, which indicates that the dual overseas background of top executives exerts the most substantial positive influence on the green innovation output level of firms.

Table 7. Test results of distinct types of overseas background

	(1) Patent	(2) Patent	(3) Patent	(4) Patent	(5) RPI	(6) RPI	(7) RPI	(8) RPI
Overseas	1.516***				0.210***			
	(12.042)				(15.507)			
OverseasW		1.450***				0.181***		
		(9.098)				(10.541)		
OverseasE			1.317***				0.171***	
			(4.007)				(4.661)	
OverseasB				2.084***				0.262***
				(8.519)				(9.832)
Size	0.274***	0.283***	0.296***	0.282***	-0.008***	-0.007**	-0.005*	-0.007**
	(10.318)	(10.575)	(11.105)	(10.615)	(-3.001)	(-2.403)	(-1.830)	(-2.420)
Lev	-0.314***	-0.305***	-0.309***	-0.302***	0.015	0.016	0.016	0.016*
	(-3.465)	(-3.386)	(-3.433)	(-3.350)	(1.527)	(1.614)	(1.564)	(1.656)
Growth	-0.001	-0.001	-0.001	-0.001	0.000	0.000	-0.000	0.000
	(-0.784)	(-1.045)	(-1.156)	(-1.079)	(0.516)	(0.082)	(-0.080)	(0.035)
ROA	0.088	0.098	0.105	0.101	-0.010	-0.009	-0.008	-0.009
	(1.162)	(1.244)	(1.344)	(1.276)	(-1.392)	(-1.149)	(-1.044)	(-1.123)
Fage	-0.430**	-0.408**	-0.420**	-0.421**	0.005	0.009	0.007	0.007
	(-2.188)	(-2.060)	(-2.076)	(-2.112)	(0.289)	(0.443)	(0.361)	(0.368)
Age	0.259	0.142	0.220	0.148	-0.008	-0.023	-0.013	-0.022
	(1.579)	(0.859)	(1.325)	(0.895)	(-0.484)	(-1.314)	(-0.761)	(-1.285)
Tenure	-0.006	-0.005	-0.005	-0.006	0.000	0.000	0.001	0.000
	(-0.474)	(-0.429)	(-0.412)	(-0.435)	(0.398)	(0.446)	(0.456)	(0.429)
_cons	-3.944***	-3.740***	-4.244***	-3.709***	0.299***	0.316***	0.254**	0.320***
	(-3.904)	(-3.666)	(-4.138)	(-3.634)	(2.976)	(3.079)	(2.480)	(3.128)
ID	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	13585	13585	13585	13585	13641	13641	13641	13641
R^2	0.753	0.750	0.747	0.750	0.650	0.638	0.628	0.636

Note: This table reports the result that overseas working experience (Overseas W), overseas studying experience (Overseas E), and overseas both working and studying experience (Overseas B) were substituted for Overseas experience (Overseas) as independent variables for regression analysis in

models (1) and (2). *, ** and *** indicate the significant level of 10%, 5% and 1% respectively.

6. Conclusion

On the basis of imprinting theory, upper echelons perspective theory, knowledge spillover effect, and behavioral finance theory, this paper utilizes balanced panel data of Shanghai and Shenzhen A-share listed companies in China from 2014 to 2021 as research samples, and mixed OLS regression model and Bootstrap methods to examine the mechanism of influence of the overseas background and risk preference tendency of top executives on corporate green innovation output level.

This study determines that the overseas background of the firm's top management team exerts a significant impact on the level of corporate green innovation output. Besides, the richer the overseas background of the top management team, the greater the risk-taking propensity, which in turn elevates the corporate green innovation output. Moreover, the risk preference mediates the relationship between the overseas background of the top management team and the green innovation output of the firm. Additionally, the top executives' educational background acts as a moderating factor in the mechanism: the overseas background of the top management team can effectively compensate for its educational deficiencies. The lower the average education level of the top management team, the more pronounced the promotional impact of their overseas background on their risk preference level. Except for that, there's a positive relationship between the top executives' overseas background and the number of green innovation citations, which indicates that the top executives' overseas background enhances the quality of the corporate green innovation output. Furthermore, there is an inverted U-shaped curve between the risk preference of the top management team and the corporate green innovation output level. Neither the risk-averse nor the risk-seeking top management team is conducive to the enterprise's innovation output, innovation output can only be augmented by elevating the risk preference tendency within an appropriate range. Finally, in comparison to only working overseas or studying overseas, the dual overseas background of top executives exerts the most significant positive impact on corporate green innovation.

To promote corporate green innovation and the high-quality development of the economy and society, this paper offers recommendations from three perspectives: government, enterprise, as well as individual. From the government's perspective, this paper proposes comprehensive training, introducing, as well as utilizing talent, continuing the preferential policy for overseas students and workers returning to China, and enhancing the implementation of the high-level returnee talent introduction plan. From the enterprise's perspective, this paper proposes that a firm's talent evaluation index system should consider a candidate's overseas experience when selecting high-level talent, to provide overseas-experienced candidates with more opportunities for advancement. Additionally, there should be an increase in opportunities for international training and exchange programs for the top executives of qualified businesses. In the process of corporate green innovation decision-making, it is recommended that the top management team should neither excessively prefer nor avoid risk, but instead, increase the risk preference tendency within a reasonable range to aid businesses in generating higher-quality green innovation outputs. From the

individual's perspective, this study advocates for talents to fully seize the opportunities of studying and working overseas, enrich their knowledge and broaden their horizons, and actively return to China to participate in the research and development of new technologies and new products, being bold in innovation and embracing challenges. At the same time, those with advanced degrees should forge ahead, be more inclined to embrace risks, and generate higher-quality green innovation outputs.

The theoretical contributions are as follows: first, the current research focuses primarily on the direct effect of the top executive's characteristics on corporate green innovation activities, and few scholars have systematically investigated its indirect influence mechanism. This paper introduces the moderating variable "risk preference of the top management team" and takes into account the moderating effects of the top management team's educational background on the pathway. The research results have a certain reference value to enrich the influence mechanism of the top management team's characteristics on corporate green innovation. Besides, the second finding of this study is that there is an inverted U-shaped relationship between the risk preference tendency of top executives and the corporate green innovation output level. This research challenges the hypothesis suggesting that the two variables exhibit solely a linear relationship as proposed in previous studies, thus contributing to the enrichment of relevant literature on the influence mechanism of the top management team's risk preference. Moreover, the practical significance and practical value of this study are as follows: in the first place, from the micro-perspective of firm management, this paper identifies that the overseas background of the top management team holds significant importance in fostering the corporate green innovation output, and the research results offer an empirical foundation for improving the selection and training of high-level talents in Chinese enterprises. Second, this paper identifies and analyzes the micro-factors that influence corporate green innovation, which assists firms in enhancing their green innovation level and green innovation quality through recruiting overseas high-level talent and moderately increasing their risk preference, thereby motivating firms to advance new technologies and attain sustainable, green development. This study concludes that both risk-averse and risk-seeking top management teams are not conducive to corporate green innovation and that innovation can only be stimulated by a moderate elevation in risk preference. This conclusion holds practical significance for firms to control their risk preference level, standardize their corporate governance system, enhance their supervision and restriction mechanisms, as well as foster stable and environmentally conscious economic and social growth.

Declarations of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Acknowledgements

None.

References

Amore, M.D., and Bennedsen, M. (2016). Corporate governance and green innovation. *Journal of Environmental Economics and Management* **75**, 54-72. Doi:10.1016/j.jeem.2015.11.003

Bhattacharya, U., Hsu, P.H., Tian, X., and Xu, Y. (2017). What affects innovation more: policy or policy uncertainty? *Journal of Financial and Quantitative Analysis* **52**(5), 1869-1901. Doi:10.1017/S0022109017000540

Chen, S., Bu, M., Wu, S., and Liang, X. (2015). How does TMT attention to innovation of Chinese firms influence firm innovation activities? A study on the moderating role of corporate governance. *Journal of Business Researc*, **68**(5), 1127-1135. Doi:10.1016/j.jbusres.2014.11.002

Chen, Y., Chang, C., and Wu, F. (2012). Origins of green innovations: The differences between proactive and reactive green innovations. *Management Decision* **50**(3), 368-398. Doi:10.1108/00251741211216197

Cho, C., Halford, J.T., Hsu, S., and Ng, L. (2016). Do managers matter for corporate innovation? *Journal of Corporate Finance* **36**, 206-229. Doi:10.1016/j.jcorpfin.2015.12.004

Dai, O., and Liu, X. (2009). Returnee entrepreneurs and firm performance in Chinese high-technology industries. *International Business Review* **18**(4), 373-386. Doi:10.1016/j.ibusrev.2009.03.004

Farag, H., and Mallin, C. (2018). The influence of CEO demographic characteristics on corporate risk-taking: Evidence from Chinese IPOs. *The European Journal of Finance* **24**(16), 1528-1551. Doi:10.1080/1351847X.2016.1151454

Gao, K., Wang, L., Liu, T., and Zhao, H. (2022). Management executive power and corporate green innovation: Empirical evidence from China's state-owned manufacturing sector. *Technology in Society* **70**, 102043. Doi:10.1016/j.techsoc.2022.102043

Giaccone, S.C., and Magnusson, M. (2022). Unveiling the role of risk- taking in innovation: Antecedents and effects. *R&D Management* **52**(1), 93-107. Doi:10.1111/radm.12477

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

Hao, Y., Fan, C., Long, Y., and Pan, J. (2019). The role of returnee executives in improving green innovation performance of Chinese manufacturing enterprises: Implications for sustainable development strategy. *Business Strategy and the Environment* **28**(5), 804-818. Doi:10.1002/bse.2282

He, X., and Jiang, S. (2019). Does gender diversity matter for green innovation? *Business Strategy and the Environment* **28**(7), 1341-1356. Doi:10.1002/bse.2319

Hirshleifer, D., Low, A., and Teoh, S.H. (2012). Are overconfident CEOs better innovators? *The Journal of Finance* **67**(4), 1457-1498. Doi:10.1111/j.1540-6261.2012.01753.x

Huang, M., Li, M., and Liao, Z. (2021). Do politically connected CEOs promote Chinese listed industrial firms' green innovation? The mediating role of external governance environments. *Journal of Cleaner Production* **278**, 123634.

Doi:10.1016/j.jclepro.2020.123634
Lee, H.U., and Park, J.H. (2008). The influence of top management team international exposure on international alliance formation. *Journal of Management Studies* **45**(5), 961-981. Doi:10.1111/j.1467-6486.2008.00772.x
Li, H., Zhang, Y., Li, Y., Zhou, L.A., and Zhang, W. (2012). Returnees versus locals: Who perform better in China's technology entrepreneurship? *Strategic Entrepreneurship Journal* **6**(3), 257-272. Doi:10.1002/SEJ.1139
Li, R., Cui, Y., Zheng, and Y. (2021). The impact of corporate strategy on enterprise innovation based on the mediating effect of corporate risk-taking. *Sustainability* **13**(3), 1023. Doi:10.3390/su13031023
Lin, C., Lin, P., Song, F. M., and Li, C. (2011). Managerial incentives, CEO characteristics and corporate innovation in China's private sector. *Journal of Comparative Economics* **39**(2), 176-190. Doi:10.1016/j.jce.2009.12.001
Liu, B., Ju, T., Bai, M., and Yu, C.F. (2021a). Imitative innovation and financial distress risk: The moderating role of executive foreign experience. *International Review of Economics & Finance* **71**, 526-548. Doi:10.1016/j.iref.2020.09.021
Liu, X., Lu, J., Filatotchev, I., Buck, T., and Wright, M. (2010). Returnee entrepreneurs, knowledge spillovers and innovation in high-tech firms in emerging economies. *Journal of International Business Studies* **41**(7), 1183-1197. Doi:10.1057/jibs.2009.50
Liu, Y., Wang, A., and Wu, Y. (2021b). Environmental regulation and green innovation: Evidence from China's new environmental protection law. *Journal of Cleaner Production* **297**, 126698. Doi:10.1016/j.jclepro.2021.126698
Lv, Y., and Chen, X. (2023). Executive vertical concurrently to enterprise green innovation. *Frontiers in Business, Economics and Management* **8**(3), 134-138. Doi:10.54097/fbem.v8i3.7825
Pan, W., Cao, H., and Liu, Y. (2023). "Green" innovation, privacy regulation and environmental policy. *Renewable Energy* **203**, 245-254. Doi:10.1016/j.renene.2022.12.025
Quan, X., Ke, Y., Qian, Y., and Zhang, Y. (2023). CEO foreign experience and green innovation: Evidence from China. *Journal of Business Ethics* **182**, 535-557. Doi:10.1007/s10551-021-04977-z
Rahko, J. (2016). Internationalization of corporate R&D activities and innovation performance. *Industrial and Corporate Change* **25**(6), 1019-1038. Doi:10.1093/icc/dtw012
Rehfeld, K.M., Rennings, K., and Ziegler, A. (2007). Integrated product policy and environmental product innovations: An empirical analysis. *Ecological Economics* **61**(1), 91-100.
Ren, S., Wang, Y., Hu, Y., and Yan, J. (2021). CEO hometown identity and firm green innovation. Bus. *Business Strategy and the Environment* **30**(2), 756-774. Doi:10.1002/bse.2652
Saunila, M., Ukko, J., and Rantala, T. (2018). Sustainability as a driver of green innovation investment and exploitation. *Journal of Cleaner Production* **179**, 631-641. Doi:10.1016/j.jclepro.2017.11.211

Shen, C., Li, S., Wang, X., and Liao, Z. (2020). The effect of environmental policy tools on regional green innovation: Evidence from China. *Journal of Cleaner Production* **254**, 120122. Doi:10.1016/j.jclepro.2020.120122

Sun, Y., Zhao, L., and Lin, C. (2023). The Impacts of Executive Equity on Green Corporate Innovation. *Sustainability* **15**(3), 9887. Doi:10.3390/su15139887

Tang, X., Shi, J., Han, J., Shu, A., and Xiao, F. (2021). Culturally diverse board and corporate innovation. *Accounting & Finance* **61**(4), 5655-5679. Doi:10.1111/acfi.12772

Wan, X., Wang, Y., Qiu, L., Zhang, K., and Zuo, J. (2022). Executive green investment vision, stakeholders' green innovation concerns and enterprise green innovation performance. *Frontiers in Environmental Science* **10**, 997865. Doi:10.3389/fenvs.2022.997865

Wang, D. (2021). Executive overconfidence and green innovation. E3S Web of Conferences. *EDP Sciences* **275**, 02053. Doi:10.1051/e3sconf/202127502053

Wang, D., Luo, Y., Hu, S., and Yang, Q. (2022b). Executives' ESG cognition and enterprise green innovation: Evidence based on executives' personal microblogs. *Frontiers in Psychology* **13**, 1053105. Doi:10.3389/fpsyg.2022.1053105

Wang, H., Qi, S., Zhou, C., Zhou, J., and Huang, X. (2022a). Green credit policy, government behavior and green innovation quality of enterprises. *Journal of Cleaner Production* **331**, 129834. Doi:10.1016/j.jclepro.2021.129834

Wernerfelt, B. (1984). A resource: based view of the firm. *Strategic Management Journal* **5**(2), 171-180. Doi:10.1002/smj.4250050207

Xia, L., Gao, S., Wei, J., and Ding, Q. (2022). Government subsidy and corporate green innovation: Does board governance play a role? *Energy Policy* **161**, 112720. Doi:10.1016/j.enpol.2021.112720

Xiang, X., and Yi, B. (2022). Directors' foreign experience and firm innovation. *Emerging Markets Finance and Trade* **58**(11), 3248-3264. Doi:10.1080/1540496X.2022.2037417

Xie, R., Yuan, Y., and Huang, J. (2017). Different Types of Environmental Regulations and Heterogeneous Influence on "Green" Productivity: Evidence from China. *Ecological Economics* **100**(132), 104-112. Doi:10.1016/j.ecolecon.2016.10.019

Yang, M., and Wang, H. (2023). The decision of investment and financial influenced by executives with overseas values: Based on individualism-overconfidence. *Applied Economics*, 1-19. Doi:10.1080/00036846.2023.2216441

Yuan, R., and Wen, W. (2018). Managerial foreign experience and corporate innovation. *Journal of Corporate Finance* **48**, 752-770. Doi:10.1016/j.jcorpfin.2017.12.015

Zhang, Y., Liu, H., and Li, M. (2022). Does chief executive officer turnover affect green innovation quality and quantity? Evidence from China's manufacturing enterprises. *Environmental Science and Pollution Research* **30**(34), 81760-81782. Doi:10.1007/s11356-022-20365-0

Zhang, Y., and Ye, J. (2021a). Risk preference of top management team and the failure of technological innovation in firms-based on principal component analysis and probit regression. *Journal of Intelligent & Fuzzy Systems* **40**(1), 1161-1173. Doi:10.3233/JIFS-201516

Zhang, Y., and Ye, J. (2021b). The impact of risk preference of top management team on re-innovation behavior after innovation failure. *Journal of Intelligent & Fuzzy Systems* **40**(6), 11051-11061. Doi:10.3233/JIFS-202186

Zhao, W., Feng, T., Xin, X., and Hao, G. (2021). How to respond to competitors' green success for improving performance: The moderating role of organizational ambidexterity. *Business Strategy and the Environment* **30**(1), 489-506. Doi:10.1002/bse.2633

Appendix 1 Variable definitions

Variable	Tab	Measurement
Green Innovation output	*Patent*	The natural logarithm of one plus firm's all green patents applications, including invention patents, design patents, and utility model patents
	Patentquote	The natural logarithm of one plus the number of citations of all green patents
Top executives' overseas background	*Overseas*	Number of top executives with overseas background/total number of top executives
	OverseasW	Overseas working background: number of top executives with overseas working background /total number of top executives
	OverseasE	Overseas studying background: number of top executives with overseas studying background /total number of top executives
	OverseasB	Dual overseas background: number of top executives with both overseas background /total number of top executives
Top executives' risk preference index	*RPI*	Risk asset/total asset= (Trading financial assets + receivables + available-for-sale financial assets + held-to-maturity investments + investment real estate)/Total assets.
	SRPI	Short-term risk preference: the proportion of short-term risk assets= (trading financial assets + receivables)/current assets.
	LRPI	Long-term risk preference: the proportion of long-term risk assets= (available-for-sale financial assets + held-to-maturity investments + investment real estate)/non-current assets.
Top executives' education level	*Education*	Number of top executives with master's degree or above/total number of top executives
Firm size	*Size*	Ln (firm's total assets)
Financial Leverage ratio	*Lev*	Total liabilities/total assets

Sale growth rate	*Growth*	The firm's net profit growth rate
Return on asset	*ROA*	Net income/average assets
Firm's age	*Fage*	Ln(fiscal year t minus the year the firm was established)
Top executives' age	*Age*	Ln(Average age of the top executives)
Top executives' tenure	*Tenure*	Ln(Average tenure of the top executives)
Year	Year	The sample period is from 2014 to 2021.
Industry	Industry	According to China Securities Regulatory Commission (CSRC) industry classification standard