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Article

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Does cross-listing on the Hong Kong stock exchange affect Chinese firms' green innovation? New evidence

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ABSTRACT

Green innovation is a costly and risky process that enables firms to improve their energy efficiency and maintain sustainable growth. In this study, we investigate whether cross-listing shares in developed markets encourages firms from developing markets to engage in green innovation. By analyzing a sample of firms that are simultaneously listed on the Chinese A-share market and the Hong Kong Stock Exchange, the study finds that cross-listed firms have more green patent applications, patent grants, and citations than non-cross-listed firms. The transmission mechanisms suggest that cross-listed firms are motivated by foreign investors' expectations of sustainable growth to engage in green innovation. Furthermore, in developed capital markets, high-quality firms can receive capital at low costs and use it to support valuable green innovation. As a result, cross-listed firms demonstrate better environmental performance after cross-listing, and green innovation products (patents) enable cross-listed firms to improve their financial performance. Overall, we establish a relationship between cross-listing and green innovation and highlight a new factor that leads firms to undertake valuable green innovation.

1. Introduction

With global warming and environmental problems posing continuous threats to global development, green innovation has become a major focus in recent years. China has experienced rapid growth in recent decades, becoming the second largest economy in the world. However, its economic growth is associated with high energy consumption, high carbon emissions, and environmental pollution (Sha et al., 2022). In 2018, the air quality in China ranked fourth to last according to the Report of Global Environmental Performance Index (Chen & Ma, 2021). Additionally, China's oil import dependency exceeded 70% in the same year, suggesting a large demand for international crude oil resources (Xiao et al., 2022). To address the ongoing environmental problems and maintain energy safety, it has become increasingly urgent for Chinese society to adopt green development strategies and undertake green innovation.

Green (technology) innovation refers to the development of new technologies, processes, and products that can reduce environmental pollution and improve the efficiency of energy (and other raw materials) utilization (Zhang et al., 2021). Green innovation enables firms to

decrease their energy reliance and mitigate environmental problems, which can reduce environmental litigation risk and contribute positively to firm performance (Zhang, Rong, & Ji, 2019; Chen & Ma, 2021). However, green innovation is considered to be costly and risky, which leads innovation firms to maintain long-term investment but may not yield a profitable product (Sha et al., 2022). Therefore, a main issue is whether firms use green technology and engage in green innovation.

Cross-listing enables domestic firms to raise funds in foreign markets and expands investors' base (Bris et al., 2012; King & Segal, 2009). The private sector in China has experienced considerable expansion in recent decades, with the percentage of private enterprises increasing from less than 20% in 1996 to more than 70% in 2012 (Filip et al., 2020). As such, rapidly developing enterprises may become capital hungry if they are unable to secure sufficient capital to support their expansion in domestic capital markets. In such cases, enterprises often resort to international markets, with the Hong Kong Stock Exchange (HKEX) being the nearest and most popular. In 1993, only six Chinese A-share market firms were cross-listed on the HKEX; by 2021, the number of domestic firms cross-listed on the HKEX reached 135.¹ Studies suggest that Chinese mainland firms can expand their financing sources by introducing

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¹ The data come from HKEX.

foreign capital, and Hong Kong investors can typically provide low-cost funds (Feng et al., 2022; He et al., 2024; Lyu et al., 2023; Sha et al., 2022). Information advantages ensure that Hong Kong investors are exposed to low risks and thus they require a low premium. Therefore, firms in which Hong Kong investors invest have relatively sufficient low-cost external funds with which to conduct green innovation and thus invest more in green innovation (Feng et al., 2022; Lyu et al., 2023; Sha et al., 2022).

Cross-listed firms typically need to appeal to the norms and values of foreign stakeholders (e.g., investors and media) and adhere to the litigation and enforcement environments of the host market. This allows them to build a good reputation and overcome the liability of being foreign (King & Segal, 2009; Reiter, 2021; Tourani-Rad et al., 2016). As Sha et al. (2022) suggest, investors from Hong Kong markets are more concerned with carbon emissions and environmental protection than mainland investors. Therefore, Hong Kong investors may participate in firms' management and guide domestic firms to engage in green activities. They may require firm managers to disclose information related to green activities, thus leading domestic firms to increase their green innovation investment. Firms may also cater to Hong Kong investors' preference for green innovation investment by increasing their level of green innovation, thereby improving their reputation among and becoming more attractive to Hong Kong investors (Feng et al., 2022; Sha et al., 2022).

The environmental protection and green information disclosure regulations in the Hong Kong market are better developed than those in the mainland market. For example, in 2021, the HKEX released the "Climate Information Disclosures Guide" and the "Practical Net-Zero Guide for Business," with the former regarded as the most advanced climate information disclosure regulations in China and the latter representing the most up-to-date guidelines for listed firms to achieve zero emissions. As cross-listed firms effectively "bond" themselves to the advanced environmental regulations in the Hong Kong market, they should aim to meet the requirements of such regulations. They can do this by adopting environmentally friendly policies and increasing their investment in environmental protection (e.g., green innovation), subsequently enhancing their green innovation performance (Sha et al., 2022; Weng et al., 2015).

In this study, we investigate the impact of cross-listing on green innovation. Using a sample of Chinese firms cross-listed on the HKEX, we demonstrate that cross-listed firms (1) invest more in green innovation after cross-listing than before cross-listing and (2) invest more in green innovation than non-cross-listed firms. The transmission mechanisms indicate that cross-listing increases stock price informativeness. Therefore, cross-listed firms' managers learn from information released by stock prices, which reflects Hong Kong investors' beliefs about green development, and enhance their green innovation investment accordingly. Furthermore, cross-listed firms that commit to value and regulation systems in the Hong Kong market tend to make additional green innovation investments. Finally, cross-listed firms can raise more low-cost capital in the Hong Kong market, which facilitates green innovation and leads firms to increase their level of green innovation investment. We also analyze the financial and environmental performance of cross-listed firms when they engage in green innovation. The analysis results indicate that cross-listed firms with high levels of green innovation investment demonstrate an increase in environmental and financial performance after cross-listing, indicating that green innovation contributes to cross-listed firms' performance.

Our empirical results contribute to the literature in three ways. First, studies indicate that stakeholders' green preferences drive firms' willingness to engage in green innovation (Quan et al., 2023; Zhang et al., 2020). Zhang et al. (2020) show that firms may be motivated to enhance their green innovation investment if doing so would align with investors' preferences for green development, as it could help them secure capital from these investors. Quan et al. (2023) find that a firm's green innovation investment is driven by customers' awareness of

environmental protection, as firms need to meet the preferences of customers and increase their market share. In contrast, when firms operate in a market with weak environmental awareness, they may not pay attention to environmental problems. However, the aforementioned studies only focus on one market and ignore the situation of cross-listing. We demonstrate that when firms cross-list their shares and raise capital in foreign markets, they are influenced by the norms and regulations of both domestic and foreign markets. Therefore, firms that face weak environmental restrictions in the domestic market may also be governed by strict green regulations in the foreign market and engage in green innovation.

Second, studies suggest various advantages of cross-listing, including overcoming the segment of investments, expanding investors' bases, receiving low-cost funds in foreign capital markets (Bris et al., 2012; King & Segal, 2009), improving corporate governance (Ayyagari & Doidge, 2010; Charitou et al., 2007), increasing stock price informativeness (Bris et al., 2012; Li et al., 2015), and mitigating information asymmetry (Bris et al., 2012). However, none of these studies focus on green innovation in cross-listed firms. As mentioned above, firms undertaking green innovation aim to establish a sustainable business model that meets their need to improve energy efficiency, reduce production costs, and solve environmental problems. With green development receiving increasing attention from market investors and customers around the world, engaging in green activities enables firms to enhance their corporate reputation and competitive advantage in the market. In this study, we explore the impact of cross-listing on green innovation and demonstrate that cross-listing prompts firms to engage in green innovation. Green innovation, in turn, contributes to both corporate green performance and financial performance.

Third, previous studies fail to reach a consensus on the relationship between green innovation and firm performance. Some studies argue that green innovation can reduce production costs and enhance reputation and market share, which contributes to firm performance (Tang, Walsh, Lerner, Fitza, & Li, 2018; Hao, Chen, & Chen, 2022). Others cast doubts on this argument and posit that green innovation harms firm performance, as it may draw managers' attention away from seeking profitable projects and maximizing corporate profit (Chen & Ma, 2021; Sha et al., 2022). We add to the literature on green innovation performance by demonstrating that pressure from stakeholders leads firms to engage in green innovation. Firms that enhance their green innovation investment to align with stakeholder preferences for green development can improve their image and competitive advantage by doing so, which would ultimately contribute to firm performance.

The remainder of this paper is organized as follows: Section 2 provides the literature review and hypothesis development. Section 3 describes the data and methodology. Section 4 explains the empirical results. Section 5 presents the conclusion.

2. Literature review and hypothesis development

2.1. Hong Kong investors and green innovation

The capital market liberalization policies in mainland China allow Hong Kong investors to invest in mainland firms through many channels, including as a qualified foreign institutional investor (QFII) and via the Shanghai–Hong Kong Stock Connect (SH–HKSC) and Shenzhen–Hong Kong Stock Connect (SZ–HKSC) programs. Mainland firms can also choose to directly cross-list in the Hong Kong stock market to obtain financing from Hong Kong investors. The participation of Hong Kong investors (through capital market liberalization policies) has been perceived as a crucial factor that encourages mainland firms to conduct green innovation (Feng et al., 2022; Sha et al., 2022). Feng et al. (2022) argue that firms in which investors from Hong Kong can invest through the SH–HKSC and SZ–HKSC programs exhibit a higher level of green innovation. Firms extend their financing sources after introducing foreign capital and can thus receive low-cost foreign funds to support

their green innovation activities. As green innovation is risky and may exert a strong spillover effect, such innovation may not secure sufficient external funds in the domestic market. However, foreign investors can establish well-diversified portfolios to diversify their investment risks, as they can participate in multiple markets. Therefore, foreign investors are often willing to provide low-cost funds to support firms' risky green innovation projects and contribute to their overall green innovation (Feng et al., 2022). Hong Kong investors also serve as a driver of green innovation, providing green governance to the managers of domestic firms. Typically, green innovation can increase industry competition though the spillover effect; therefore, firms may not disclose detailed information about green innovation. However, foreign investors' monitoring may require firms to reveal such information. The increased level of green information disclosure, in turn, leads firms to invest in green innovation (Feng et al., 2022; Sha et al., 2022). Sha et al. (2022) argue that capital market liberalization (e.g., SH–HKSC and SZ–HKSC) is positively related to green innovation because of the associated mitigation of information problems and improved environmental awareness among managers. Hong Kong investors are typically sophisticated in collecting and analyzing fundamental information. When they participate in stock market trading, they may incorporate such information into the stock price. Informative stock pricing reveals information about the value of firms' investment opportunities, which can be captured by firm managers. The importance of carbon awareness and environmental protection is widely recognized among consumers and investors from developed markets. Given that they often pay more attention to corporate green activities, firms' green innovation is likely to draw the attention of foreign investors, leading to the firms' stock prices reflecting information about their green investment opportunities (Sha et al., 2022). Managers can learn from such stock prices, capture valuable green investment opportunities, and increase their investment in green innovation projects accordingly. Firms may also be motivated by the green preferences of Hong Kong investors to increase their investment in green innovation with the goal of strengthening their reputation. In this context, Hong Kong investors compel domestic firms to pursue green development and green activities. That is, investor pressure serves as the main driving force of corporate green innovation (Sha et al., 2022).

Similarly, Lyu et al. (2023) focus on the SH–HKSC and SZ–HKSC programs and find a positive relationship between stock market liberalization and corporate green innovation. They argue that foreign institutional investors can receive more market information and enable stock prices to reflect such information. When managers learn from stock prices, their resource allocation decisions are guided by the information contained in a stock's price. Accordingly, when stock prices reveal investors' preference for green innovation, managers will conform to investor expectations and increase their green innovation investment. Foreign institutional investors may further provide direct monitoring on green innovation performance. Foreign investors may bring advanced green technology and management experience to domestic firms, which also facilitate firms' green innovation activities. He et al. (2024) suggest that capital market opening policies (SH–HKSC and SZ–HKSC) enable domestic firms to receive advanced governance and financing resources from Hong Kong investors. As Hong Kong investors are more aware of environmental protection than domestic investors, they may pressure the managers of domestic firms to focus on green activities and disclose more green information. They also serve as a new source of financing that supports firms' green innovation projects. Therefore, firms in which Hong Kong investors invest have a strong tendency to engage in green innovation. Wang et al. (2023) show that Hong Kong investors value firms' social and environmental performance more than mainland investors do. Therefore, when Hong Kong investors invest in Chinese mainland firms through the SH–HKSC and SZ–HKSC programs, the managers of these firms may cater to Hong Kong investors and increase their environmental, social, and governance investments. This catering incentive is stronger when firms are in urgent need of external funds.

In general, Hong Kong investors can mitigate mainland firms' financial constraints, improve their governance and green information disclosure, and guide their green innovation investments. Therefore, capital market liberalization policies (e.g., SH–HKSC and SZ–HKSC), which facilitate the investment activities of Hong Kong investors, are positively associated with corporate green innovation. However, prior studies mainly focus on the effects of the SH–HKSC and SZ–HKSC programs on corporate green innovation investment and performance and fail to address the case where Chinese mainland firms cross-list their shares on the HKEX. Compared with the mainland market, the Hong Kong market has strict environmental protection and information disclosure regulations (e.g., the Climate Information Disclosures Guide and Practical Net-Zero Guide for Business). Cross-listed firms need to follow such strict regulations rather than merely face the soft disclosure expectations of Hong Kong investors. According to Cui et al. (2022) and Sha et al. (2022), green innovation is largely driven by environmental regulations. Strict regulation forces firms to improve their green innovation performance and information disclosure, requiring them to engage in green innovation and meet requirements. Therefore, we expect cross-listed firms, which are under the pressure of market regulations, are prone to increasing their green innovation. Cross-listed firms must also compete with foreign firms and overcome the liability of being foreign (Bosco & Misani, 2016; Reiter, 2021). In contrast, firms in which Hong Kong investors invest through the SH–HKSC and SZ–HKSC programs simply face the domestic environment, with their shareholders being largely from mainland China. Therefore, cross-listed firms may have strong incentives to cater to Hong Kong investors and stakeholders and gain competitiveness. Accordingly, it is necessary to investigate the green innovation behaviors of cross-listed firms.

2.2. Bonding hypothesis and stakeholder pressure

Cross-listing allows firms to extend their shareholder base and access low-cost financing. However, cross-listed firms must commit to the norms and values of their host countries. Cross-listed firms tend to attract foreign investors with private information and sophisticated analysis techniques; this allows them to build a large group of investors and take advantage of the diverse information they release (Bris et al., 2012; King & Segal, 2009). To expand their investor base and attract foreign investment, managers and shareholders must appeal to foreign investors by following the norm and value systems of the host market and disclosing information to indicate their willingness to do so (Bosco & Misani, 2016). Such commitment to norms, values, and expectations signals firms' respect for the value systems of host countries, which appeals to foreign investors and attracts their participation (Bosco & Misani, 2016).

Cross-listed firms also tend to satisfy other stakeholders (e.g., the government and the media) in host countries, as they must overcome the liability of foreign companies and compete with foreign companies when seeking funds in a foreign capital market (Bosco & Misani, 2016; Reiter, 2021). Investors unfamiliar with cross-listed foreign firms may overestimate their operating risk and require compensation for such risk (the liability of foreignness). Cross-listed firms can improve their image and reputation by establishing solid relationships with their stakeholders, thus portraying themselves in a positive light (e.g., low operating risk) and reducing the cost of being foreign (King & Segal, 2009; Reiter, 2021; Tourani-Rad et al., 2016). They can further maintain such strong relationships with their stakeholders by upholding stakeholder values. In general, firms' tendency to meet social expectations and improve their reputations in host countries reflects the reputational bonding effect of cross-listing.

Accordingly, some social and market pressures may drive firms' green innovation decisions (Zhang et al., 2020, 2021). For example, investors' and stakeholders' preferences for green production and investment may guide firms in choosing a clean production process and enhancing green innovation (Zhang et al., 2021). Foreign investors also

intervene in corporate governance and send information about environmental protection, which encourages managers to adopt green growth strategies (Zhang et al., 2021). As mentioned earlier, Hong Kong investors and stakeholders recognize the importance of carbon awareness and environmental protection, making them likely to pay close attention to firms' green innovation performance. Therefore, when firms have a high demand for funds from Hong Kong investors, they should align with these investors' preferences and pursue green innovation to improve their green innovation performance (Sha et al., 2022). Hong Kong investors may pressure firms to disclose green-related information, which forces them to be environmentally friendly and disclose the results of their green activities. Therefore, firms increase their green innovation under the pressure of foreign investors (He et al., 2024; Lyu et al., 2023; Sha et al., 2022). Foreign investors may even directly monitor firms' green activities by bringing green technology and management experience to domestic firms. Such technology and experience enable domestic firms to rebuild their production and operating processes and help firms enhance their green innovation efficiency and achieve high green innovation performance (Lyu et al., 2023). Accordingly, cross-listed firms in mainland China, which appeal to the values and expectations of Hong Kong investors and stakeholders, may increase investment in green innovation and improve their green innovation performance. Firms may also tend to disclose information about such green innovation to attract Hong Kong investors. This would further improve their image and overcome the liability of being foreign.

In addition to reputational bonding, cross-listed firms are subject to legal and regulatory systems in host countries through "legal bonding." Studies indicate that firms tend to cross-list in countries with greater investor protection and disclosure standards than in their domestic countries, allowing them to benefit from the superior governance environment (Charitou et al., 2007; Roosenboom & van Dijk, 2009). However, after cross-listing, firms need to improve information disclosure and corporate governance and bond themselves to strict foreign regulations, which prevents managers and controlling shareholders from extracting corporate resources for their personal financial benefit.

In terms of green practices, environmental laws and regulations may lead firms to pursue green production (Sha et al., 2022; Weng et al., 2015; Zhang et al., 2021). Sha et al. (2022) posit that environmental regulation and enforcement in developed markets drive firms to focus on green development and enhance their investment in green innovation. Weng et al. (2015) suggest that environmental protection regulations are widely established around the world. Firms need to change their management practices and adopt environmentally friendly policies to fulfill the requirements of such regulations. Similarly, cross-listed firms must adhere to the litigation and enforcement framework in both the mainland and Hong Kong markets (e.g., the Climate Information Disclosures Guide and Practical Net-Zero Guide for Business released by the HKEX and the Energy Development Strategic Action Plan in mainland China). In response to these double requirements, cross-listed firms need to improve their environmental protection processes and energy utility efficiency by conducting green innovation and disclosing related information (Zhang et al., 2021).

Cross-listed firms can also be influenced by foreign investors through informative stock prices. As foreign investors are sophisticated in collecting and analyzing fundamental information (e.g., the value of firms' investment opportunities), their participation in stock trading may lead stock prices to reflect such information. The information reflected by stock prices can guide managers' decision-making. For example, managers of cross-listed firms may utilize the information reflected by stock prices to allocate capital efficiently to profitable investment projects (learning effect). Therefore, the learning effect can significantly contribute to the value of cross-listed firms (Abdallah & Abdallah, 2019; Ghadhab & Hellara, 2016; Lyu et al., 2023; Sha et al., 2022).

Hong Kong investors who value environmental protection efforts may prefer firms that adopt sustainable development strategies (Lyu et al., 2023; Sha et al., 2022). They may even incorporate such

preferences into stock prices by positively reacting to firms' green practices, leading to stock price increases following corporate green activities (e.g., green technology innovation). According to the learning hypothesis, firms learning from informative stock prices may increase their investment in green technology and conduct green innovation (Lyu et al., 2023; Sha et al., 2022). Their stock prices would in turn experience a further increase as a result of green innovation. Accordingly, the following hypothesis is proposed.

H1a. Cross-listed firms increase their green innovation investment after cross-listing.

However, green innovation may not contribute to shareholder wealth, as costly green activities have a strong spillover effect and sometimes benefit competitors in the industry (Chen & Ma, 2021; Sha et al., 2022). Green technology advancement is sometimes forced by social and government pressures, which waste corporate resources and draw managers' attention away from maximizing shareholders' interests (Chen & Ma, 2021). Green innovation is also a long-term process with uncertain results (innovation may not ensure a profitable result, such as green products), which prevents some shareholders from pursuing short-term stable profits (Sha et al., 2022). As cross-listed firms bond to strict investor protection requirements in host markets, they need to avoid investments that may harm shareholders' benefits. Therefore, the bonding effect may lead firms to reduce costly and risky green innovation activities and pursue investments that can generate stable short-term profits.

H1b. Cross-listed firms do not increase their green innovation investment after cross-listing.

2.3. Financing hypothesis and green innovation

A major benefit of cross-listing is that cross-listed firms have extended sources of financing and can obtain capital in developed markets (Bosco & Misani, 2016). They thus have access to better financing conditions. Investors from developed markets can use advanced analysis techniques to efficiently estimate the fair value of firms, which prevents mispricing (Bosco & Misani, 2016). Valuable firms can then be fairly priced and avoid paying a high financing cost. Superior financing conditions may positively affect firms' investments. Having a stable and inexpensive financing source enables firms to maintain smooth investments, which is especially crucial when they take on long-term and risky investment projects (e.g., R&D projects) (Hsu et al., 2014).

As mentioned earlier, Hong Kong investors can serve as an additional source of financing and provide low-cost funds to Chinese mainland firms, helping to ease the financial constraint problems encountered by the latter (Feng et al., 2022; He et al., 2024; Lyu et al., 2023; Sha et al., 2022). Firms conducting green innovation may have a high demand for external funds, as innovation projects typically require a large number of initial investments and a smooth investment process in the long-term. However, Chinese mainland firms sometimes face external financial constraints due to the poor information environment and related agency problems (e.g., Sha et al., 2022). This is especially the case when firms raise external funds for innovation projects, as these projects are risky and typically generate intangible assets without an accurate mortgage value and cannot be used to obtain mortgage loans (Hsu et al., 2014). Therefore, firms may forego green innovation projects due to financing problems (Sha et al., 2022). However, they can seek external financing sources outside of the mainland market and receive funds from Hong Kong investors to expand their green innovation activities. According to Feng et al. (2022) and He et al. (2024), firms in which Hong Kong investors invest are likely to engage in green innovation, mainly because they can use low-cost foreign financing to support their green innovation. Overall, this line of reasoning also leads to the initial hypothesis proposed above (H1a).

3. Data and variable definitions

3.1. Data

We use a panel dataset of firms listed on the Chinese A-share market (some of which are cross-listed on the HKEX) for the 2007–2022 period. In 2007, new accounting standards were adopted in China, resulting in dramatic changes in the value estimation of fixed assets and financial statement preparation. Therefore, we only include years after 2007. We exclude (1) financial firms (because of their special financial leverage), (2) firms with at least a 2-year deficit (especially treated firms), and (3) firms with missing governance and financial data. The final sample includes 4865 firms and 42,392 observations. We also conduct sample matching between cross-listed and non-cross-listed firms; the matching sample includes 223 firms and 3651 observations. The data are collected from the China Stock Market & Accounting Research database (e.g., Meng et al., 2020).

3.2. Green innovation

Firms engaging in green innovation develop green innovation products that contribute to sustainable development (e.g., patents). Following Sha et al. (2022), we adopt green patent applications and green patent grants as measures of green innovation in a firm. *Applications* (Grants) represents the number of green patent applications (grants) filed by firms in a year. Green patents are those contribute to energy savings, clean energy utilization, and environmental protection activities in a firm. Green patent applications and grants only reflect the quantity of green innovation products. Therefore, we also introduce a measure of quality: the number of green patent citations (*Citations*) in a year. Typically, a higher number of patent applications, grants, or citations indicates a greater tendency of firms toward green innovation. Green innovation is a long-term process, and green innovation products (and their patents) are typically generated (several years) after green innovation investment. Therefore, we estimate the effect of cross-listing on patent proxies with 1-, 2-, and 3-year lags in Section 4.3.3.

3.3. Cross-listing

In this study, we compare the green innovation of cross-listed and non-cross-listed firms as well as that of cross-listed firms before and after cross-listing. Cross-listing may encourage firms to engage in green innovation when the green innovation of cross-listed firms (after cross-listing) is greater than that of non-cross-listed firms (before cross-listing) (Boubakri et al., 2016). As the year of cross-listing varies across firms, we first apply the commonly used dynamic difference-in-differences (DID) method to perform the comparison (e.g., Meng et al., 2020). Accordingly, we construct a cross-listed firm dummy variable that equals 1 for firms that are listed on the Chinese A-share and Hong Kong H-share markets (both the main board market and others) simultaneously during the sample period, and 0 otherwise (*Cross-listing*). We also introduce a time indicator that equals 1 for the period after cross-listing and 0 otherwise (*Post*). *Post* equals 0 for non-cross-listed firms. The interaction term between *Cross-listing* and *Post* equals 1 when cross-listed firms are in the post-listing period and 0 otherwise. This interaction allows us to make the aforementioned comparison between cross-listed (post-listing) and non-cross-listed firms (pre-listing periods). We also adopt some regression methods for situations in which the treatment year varies across firms, including the stacked regression method and the method proposed by Callaway and Sant'Anna (2021) (Baker et al., 2022). Accordingly, we construct a series of dummy variables that indicate the year relative to the cross-listing year (*Pre_n* and *Post_n*, $n = 1, 2, 3 \dots$, suggesting the year relative to the cross-listing year). For example, *Post₁* (*Pre₁*) equals 1 for the first year after (before) the cross-listing year and 0 otherwise. We also introduce a dummy variable that equals 1 for the cross-listing year (*Post₀*) and

0 otherwise.

3.4. Control variables

Following Sha et al. (2022), we control for some firm characteristics that may affect firms' green innovation tendencies, including firm size (*Size*), defined as the natural logarithm of total assets, and firm age (*Age*), defined as the number of years that a firm has existed. Typically, large and mature firms have the advantage of raising external funds, which can support their green investment activities and encourage them to engage in green innovation. Other firm-related control variables include financial leverage (*Leverage*), measured as the ratio of total debt to total assets, and the ratio of fixed assets (*Fix_assets*), measured as fixed assets scaled by total assets. Firms with a lower financial leverage ratio may not face a greater burden of repaying their debts; thus, they can receive additional debt financing or raise capital in the stock market at lower costs than highly leveraged firms. Financing advantages also facilitate green practices and induce firms to engage in green innovation. We also control for the capital expenditure ratio (*Capital_exp*), measured as the ratio of capital expenditure to total assets, and the R&D spending ratio (*R&D*), calculated as R&D spending scaled by total assets. Firms' existing capital spending also affects their future investment plans, as previous investments can serve as examples and provide experience for subsequent investment projects. Other control variables include return on assets (*ROA*), calculated as net income divided by total assets, and Tobin's Q (*Q*), defined as the market value of equity plus the book value of total debt scaled by the book value of total assets. Firms with high performance and prospectation are better at attracting investors and accessing external financing. They can also generate sufficient internal funds to invest in green innovation, which is regarded as the most suitable source of financing to increase innovation.

3.5. Empirical model

As the cross-listing year varies across firms (staggered DID), we first introduce the dynamic DID model, which includes the interaction between cross-listed firms and post-listing period indicators (*Cross-listing* $\times$ *Post*), into the model (Meng et al., 2020) and estimate the relationship between green innovation proxies and the interaction term. This allows us to avoid the completely collinear problem caused by varying treatment times. Furthermore, we use propensity score matching to address the endogeneity problem. An endogeneity problem may arise when some firm-related characteristics other than cross-listing affect corporate green innovation strategies. In this scenario, cross-listing may not be the main driving force of green innovation. Our matching process yields a group of matching firms that possess the characteristics of cross-listed firms but do not cross-list their shares on foreign exchanges. Therefore, we can control for the influence of other characteristics and focus on the impact of cross-listing on green innovation. Accordingly, we first estimate the probability of cross-listing (the propensity scores) by regressing *Cross-listing* on the green innovation proxies and control variables in Equation (1) (matching variables). Then, we match one cross-listed firm with five non-cross-listed firms on the basis of nearest neighbor propensity scores. Non-cross-listed firms are matched with cross-listed firms on a year-by-year basis because the treatment year varies by firm, and the effect of cross-listing on the treated firms may vary over time. The matching process generates 85 treated (cross-listed) and 138 control (non-cross-listed) firms and a total of 3651 observations. The maximum difference between the propensity scores of the treatment and control firms is 0.009.

Following He and Shen (2024), we test the covariate balance between the treatment and control firms by comparing the means of the matched variables in the treatment firms with those in the control firms. Appendix Table A1 shows that for the pre-matched sample, the T-statistics of the differences between the treatment and control means are statistically significant, and the absolute standard differences for the

covariate means are higher than 5%. These results indicate significant differences in the means of the matching characteristics between the treatment and control firms before matching. In this scenario, differences in the matching characteristics (rather than merely cross-listing) may cause the difference in green innovation between the cross-listed (treatment) and non-cross-listed (control) firms. However, in terms of the matched sample, the absolute standard differences for the covariate means are lower than 5%, and the T-statistics of the mean differences are generally nonsignificant. These results suggest that the differences in the covariate means for the pre-matched sample are generally mitigated after matching, and firms' green innovation is mainly affected by cross-listing (rather than matching variables) in the matched sample. We also conduct a multivariate test to check the covariate balance. Specifically, we regress the *Cross_listing* dummy variable on our matching variables. If the coefficients of the matching variables are statistically significant (nonsignificant), the probability of cross-listing can (not) be explained by the matching characteristics and the cross-listed firms are (not) significantly different from the non-cross-listed firms in terms of matching characteristics. The regression results presented in column (1) of Table A2 show that some coefficients of the matching variables are statistically significant (e.g., *Applications*, *Citations*, *Size*, *Age*, *ROA*, and *R&D*) in the pre-matched sample, which indicates significant differences in some of the matching variables between the treatment and control firms before matching. However, in column (2) of Table A2, nearly all of the coefficients of the matching variables are nonsignificant after matching, which suggests that the treatment and control firms generally do not demonstrate significant differences in firm characteristics after matching, and the matching process generates a covariate-balanced matched sample.

Finally, the dynamic model is proposed as follows:

$$\text{Innovation}_{it} = \beta_1 + \beta_2(\text{Cross_listing} \times \text{Post})_{it} + \sum \beta_p \text{Control}_{it-1} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

where i denotes the firm and t reflects the year. γ_i and δ_t indicate industry and year fixed effects, respectively. ε_{it} is the error term. *Innovation* represents the green innovation proxies in Section 3.2. *Control* represents the control variables in Section 3.3. The green innovation proxies are count data, whereas commonly used regression methods (e.g., ordinary least squares, OLS) can be used only to address continuous variables. Therefore, we adopt the Poisson regression method, which is uniquely used when the dependent variable is count data. The coefficient of the interaction term (β_2) is of interest because it estimates the difference between the green innovation of cross-listed firms (after cross-listing) and that of non-cross-listed firms. A positive interaction term coefficient indicates that cross-listed firms invest more in green innovation after cross-listing than non-cross-listed firms do. That is, cross-listing prompts firms to increase their green innovation.

We further adopt the DID model modified by Callaway and Sant'Anna (2021) (CS-modified DID model), which aims to address the problem associated with the staggered DID model. According to Baker et al. (2022), the commonly used staggered DID model, which pools the sample together and only estimates the average DID effect, may result in two types of errors and generate biased estimators. These problems can be addressed by using the CS-modified DID model, which first estimates the time-specific treatment effects separately (individual effects) and then aggregates the individual effects by group to generate the estimator of the overall treatment effect. Finally, we adopt the stacked regression estimator to address the staggered DID estimation errors (Baker et al., 2022). The stacked regression method avoids the error arising from making comparisons between groups with different treatment years (Baker et al., 2022). When adopting the stacked regression method, we first construct a group in which the treatment firms with the same time period relative to the cross-listing year and non-treatment firms are included. Then, we measure the estimator on the basis of a comparison

between the treatment and non-treatment firms within the group.

4. Empirical results

4.1. Summary statistics

Table 1 shows the summary statistics of the main variables. The sample mean of the number of green patent applications (grants) is 3.333 (3.323), which is lower (lower) than the 11.930 (11.310) reported by Sha et al. (2022) using data from Chinese listed firms during the 2007–2019 period. The sample mean of *Cross_listing* is 0.027, which suggests that nearly 2.7% of the sample firms are cross-listed on the Hong Kong market. In terms of the control variables, the sample means of firm size (*Size*), financial leverage (*Leverage*), the capital expenditure ratio (*Capital_exp*), and return on assets (*ROA*) are 22.093, 0.429, 0.051, and 0.028, respectively, which are lower than the values of 22.490, 0.452, 0.052, and 0.039 reported by Sha et al. (2022). The sample mean of Tobin's Q (*Q*) is 2.054, which is greater than the value of 1.869 reported by Sha et al. (2022).

4.2. Effects of cross-listing and green innovation

In this study, we explore the impact of cross-listing on green innovation. Our empirical results are presented in Table 2. In columns (1) and (2) of Table 2, the dependent variable is *Applications* and *Grants*, respectively, measuring the quantity of innovation outputs. The coefficients of the interaction term are positive and significant (0.207 and 0.150), indicating that cross-listed firms generate more innovation outputs after cross-listing than non-cross-listed firms do. These results provide evidence to support H1a. Cross-listed firms tend to appeal to the value and legal systems in the host market, which may reveal stakeholders' preferences for sustainable development. Therefore, they are likely to engage in green innovation and generate innovation products to pursue sustainable development (Abdallah & Abdallah, 2019; Bris et al., 2012; King & Segal, 2009; Reiter, 2021; Tourani-Rad et al., 2016). Cross-listing enables firms to extend their financing sources and receive low-cost financing from Hong Kong investors, which facilitates firms' green innovation and encourages them to engage in long-term green innovation investment (Bosco & Misani, 2016). The dependent variable in column (3) is *Citations*, which measures the quality of innovation. In this column, the coefficient of the interaction term is positive and significant (0.172), indicating that firms engage in valuable green inno-

Table 1
Summary statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
<i>Applications</i>	42,392	3.333	9.779	0	67
<i>Grants</i>	42,392	3.323	9.767	0	66
<i>Citations</i>	42,392	3.503	13.557	0	100
<i>Cross_listing</i>	42,392	0.026	0.161	0	1
<i>Post</i>	42,392	0.024	0.155	0	1
<i>Size</i>	42,392	22.093	1.312	18.886	26.069
<i>Age</i>	42,392	17.577	6.090	4	33
<i>Leverage</i>	42,392	0.429	0.213	0.051	1.023
<i>Fix_assets</i>	42,392	0.212	0.162	0.002	0.711
<i>Capital_exp</i>	42,392	0.051	0.049	0.000	0.241
<i>ROA</i>	42,392	0.028	0.058	−0.273	0.205
<i>R&D</i>	42,392	0.002	0.006	0	0.038
<i>Q</i>	42,392	2.054	1.364	0.857	9.109

vation projects and that the quality of innovation significantly improves

Table 2
Effects of cross-listing on green innovation.

	(1)	(2)	(3)
	Applications	Grants	Citations
(Cross-listing*Post) _{i,t}	0.207** (2.323)	0.150*** (4.062)	0.172*** (3.500)
Size _{i,t-1}	0.919*** (21.270)	0.892*** (23.696)	0.818*** (16.672)
Age _{i,t-1}	-0.036*** (-4.803)	-0.030*** (-7.680)	-0.037*** (-6.405)
Leverage _{i,t-1}	-0.310 (-0.994)	-0.372** (-1.993)	-0.484** (-2.233)
Fix_assets _{i,t-1}	1.816*** (5.796)	-0.182 (-0.999)	-0.003 (-0.012)
Capital_exp _{i,t-1}	3.387*** (3.781)	1.238** (2.565)	1.321** (2.170)
ROA _{i,t-1}	2.386** (2.075)	0.473 (0.708)	1.388 (1.532)
R&D _{i,t-1}	7.476 (1.317)	8.572*** (2.847)	10.106*** (2.592)
Q _{i,t-1}	-0.005 (-0.071)	-0.084** (-2.233)	0.080 (1.299)
Constant	-21.905*** (-19.325)	-19.566*** (-21.803)	-16.954*** (-14.154)
Industry and year fixed effects	yes	yes	yes
Pseudo R ²	0.757	0.635	0.645
Observations	3354	3354	3354

Note: In this table, the effects of cross-listing on green innovation are presented. The variables are defined in Section 3. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

after cross-listing. The marginal effect² of cross-listing on corporate patent applications (granted patents and patent citations) is 5.748 (1.877 and 2.365). The economic explanation of this marginal effect is that cross-listed firms have 5.748 (1.877 and 2.365) more patent applications (grants and citations) after cross-listing than non-cross-listed firms do.

We also adopt the CS and stacked regression models to address the staggered DID estimation errors (Baker et al., 2022). Panel A of Table 3 reports the results of the CS DID model. The dependent variable in columns (1) to (3) is *Applications*, *Grants*, and *Citations*, respectively. The group estimation shows both positive and negative DID effects, whereas the average DID effects are positive and significant (9.020, 5.787, and 19.456), indicating that although the DID effect of cross-listing on green innovation varies with the treatment year, cross-listed firms generally increase their green innovation after cross-listing and demonstrate higher levels of green innovation than non-cross-listed firms. Panel B of Table 3 presents the results of the stacked regression model. The estimators are nonsignificant during the pre-cross-listing periods, indicating that cross-listed firms may not conduct additional green innovation activities compared with non-cross-listed firms before cross-listing. The estimators remain nonsignificant during the first 4 years of cross-listing, whereas cross-listing shows some positive effects on *Applications* and *Grants* during the 5–15 years after cross-listing. This indicates that a time lag exists between cross-listing and the onset of its positive effects. Firms may need some time to modify their green strategies and generate green products. In general, after cross-listing, cross-listed firms have a greater tendency toward green innovation and generate more innovation products than non-cross-listed firms.

4.3. Dynamic analysis

We show that cross-listed firms increase their green innovation

² The coefficient may be nonlinear when using the Poisson regression method, but the marginal effect (Stata command: margin, dydx(varlist)) indicates the linear relationship between the dependent and independent variables.

Table 3
CS and stacked DID models.

Panel A	(1)	(2)	(3)
	Applications	Grants	Citations
GAverage	9.020*** (5.171)	5.787** (2.064)	19.456*** (4.153)
Observations	37,499	37,499	37,499
Panel B	(1)	(2)	(3)
	Applications	Grants	Citations
Pre_9	2.525 (0.333)	1.267 (0.167)	16.205 (1.268)
Pre_8	2.148 (0.284)	1.112 (0.146)	14.790 (1.157)
Pre_7	5.312 (0.635)	4.504 (0.563)	12.859 (0.931)
Pre_6	6.415 (0.778)	4.718 (0.606)	20.134 (1.379)
Pre_5	7.434 (0.877)	7.092 (0.900)	19.357 (1.276)
Pre_4	6.540 (0.767)	6.458 (0.824)	12.732 (0.867)
Pre_3	9.100 (0.997)	7.424 (0.926)	20.850 (1.297)
Pre_2	8.432 (0.956)	9.574 (1.182)	22.850 (1.123)
Pre_1	-3.274 (-1.240)	-0.102 (-0.033)	-5.045 (-0.881)
Post_0	-1.223 (-0.215)	0.960 (0.171)	0.099 (0.012)
Post_1	-34.065 (-1.480)	-47.932 (-1.530)	-10.816 (-0.398)
Post_2	-15.222 (-0.880)	-22.787 (-1.136)	12.956 (0.553)
Post_3	-3.347 (-0.305)	-6.278 (-0.536)	28.584 (1.188)
Post_4	15.058 (1.264)	15.616 (1.271)	31.677 (1.308)
Post_5	25.315* (1.861)	24.644* (1.774)	31.128 (1.246)
Post_6	42.501** (2.211)	31.498* (1.917)	41.218 (1.372)
Post_7	39.198** (1.964)	52.701*** (2.726)	41.294 (1.199)
Post_8	24.232 (1.078)	36.342* (1.709)	17.976 (0.670)
Post_9	38.569 (1.380)	39.331 (1.585)	21.994 (0.766)
Post_10	48.627** (2.058)	61.579** (2.127)	17.445 (0.537)
Post_11	55.712*** (2.695)	81.021*** (2.634)	3.061 (0.065)
Post_12	68.805*** (3.255)	98.825*** (3.173)	-58.639 (-1.362)
Post_13	66.054*** (3.018)	114.060*** (3.291)	-72.210 (-1.428)
Post_14	58.567** (2.536)	119.782*** (3.324)	-97.213* (-1.852)
Post_15	58.154*** (2.652)	108.359*** (3.712)	-127.147** (-2.147)
Constant	4.765 (0.838)	2.546 (0.453)	4.493 (0.559)
R ²	0.552	0.520	0.471
Observations	1,109,449	1,109,449	1,109,449

Note: In this table, several alternative estimation methods are used. Panels A and B show the results of the CS and stacked DID models, respectively. The variables are defined in Section 3. Robust t-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

outputs and improve their innovation qualities after cross-listing. In this subsection, we conduct a dynamic analysis because endogeneity problems may drive our main results when adopting the dynamic DID model. Firms may increase their green innovation investment due to domestic factors, such as increased competition and carbon emission limits, rather than cross-listing. In this scenario, domestic factors may dominate the

changes in firms' green innovation behaviors, making cross-listing the second most important driving force and leading to endogeneity problems. The dynamic analysis allows us to determine whether the green innovation of cross-listed firms follows a parallel trend with that of non-cross-listed firms before cross-listing. Such a parallel trend would indicate that cross-listed and non-cross-listed firms possess similar characteristics and encounter similar operating and financing environments in the domestic market. Therefore, the green innovation of cross-listed firms may not differ significantly from that of non-cross-listed firms before cross-listing, and the increase in cross-listed firms' green innovation may mainly be caused by cross-listing rather than domestic factors.

Accordingly, we construct a series of time indicators (dummy variables) that equal 1 for 1–2 years before cross-listing ($Pre(1,2)$), the cross-listing year, 1–2 years after cross-listing ($Post(1,2)$), and up to more than 7 years after cross-listing ($Post(*)$). We include these year indicators in Equation (1) and present the regression results in Table 4. In Table 4, the coefficients of $Pre(1,2)$ and $Post(0)$ are nonsignificant, whereas the coefficients of $Post(1,2)$, $Post(3,4)$, $Post(5,6)$, and $Post(7)$ are positive and significant, indicating that the innovation outputs of cross-listed firms significantly increase after cross-listing. However, before the cross-listing year, as the innovation outputs of cross-listed firms and those of non-cross-listed firms do not differ significantly, they do exhibit a parallel trend. Therefore, the increase in the green innovation of cross-listed firms is driven mainly by cross-listing.

4.4. Effect of the time lag

Green innovation is regarded as a long-term investment process that may persist for several years. Therefore, there is a time lag between innovation inputs (investments) and outputs (patents). As we adopt patents as a proxy for green innovation, we must consider the potential time lag between the changes in firms' green innovation investments and the production of green patents after cross-listing. Accordingly, we adopt 1-year (2-year and 3-year) lagged patent proxies as dependent variables and include them in Equation (1) (Sha et al., 2022). The regression results are presented in Table 5. The coefficients of the interaction term are positive and significant, indicating that cross-listing encourages firms to invest in green innovation activities, which increases the number of green patent applications (grants and citations). In general, our baseline results hold after we consider the

Table 4
Dynamic analysis.

	(1)	(2)	(3)
	Applications	Grants	Citations
$Cross_listing*Pre(1,2)_{i,t}$	-0.071 (-0.226)	0.033 (0.103)	0.263 (0.653)
$Cross_listing*Post(0)_{i,t}$	-0.302 (-0.765)	-0.147 (-0.496)	-0.015 (-0.031)
$Cross_listing*Post(1,2)_{i,t}$	0.658** (2.002)	0.592* (1.668)	0.956*** (4.250)
$Cross_listing*Post(3,4)_{i,t}$	0.615*** (3.142)	0.697*** (2.879)	0.772*** (4.421)
$Cross_listing*Post(5,6)_{i,t}$	0.438** (2.370)	0.356** (1.976)	0.752*** (4.247)
$Cross_listing*Post(7)_{i,t}$	0.193** (2.206)	0.153* (1.741)	0.237*** (2.621)
Constant	-19.986*** (-21.009)	-20.155*** (-20.981)	-24.054*** (-17.053)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.775	0.799	0.835
Observations	3354	3354	3354

Note: In this table, the results of the dynamic analysis are presented. The variables are defined in Sections 3 and 4.3. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

time-consuming process of green innovation.

4.5. Stakeholder pressure

As the concepts of green development and low-carbon production have been widely accepted by foreign investors, they may have greater expectations around firms' green practices than domestic investors. Furthermore, the strict green litigation and enforcement mechanism in host countries may force cross-listed firms to improve their green information disclosure and engage in green innovation (e.g., Balli et al., 2022). To meet green expectations and adhere to litigation requirements in the host market, cross-listed firms may disclose green information and receive (avoid) green-related awards (punishments). In doing so, they can convey positive signals regarding their green innovation performance, thereby demonstrating their respect for the norms and litigation in the host country and satisfying foreign investors. In this subsection, we explore whether firms increase their green innovation engagement when they cater to foreign market expectations by disclosing green information and receiving (avoiding) green awards (punishments).

We construct a series of green disclosure dummy variables, including the carbon emissions disclosure dummy, which equals 1 if firms begin to disclose the concentration of CO₂ after cross-listing and 0 otherwise ($CO2_disclosure$); the green reputation disclosure dummy, which equals 1 if firms begin to disclose environmental protection honors or awards after cross-listing and 0 otherwise ($Reputation_disclosure$); and the environmental investment disclosure dummy, which equals 1 if firms begin to disclose environmental protection investments after cross-listing and 0 otherwise ($Environmentinv_disclosure$). We interact $Cross_listing$, $Post$, and these disclosure dummy variables and include the interaction terms in Equation (1). In Table 6, the coefficients of the interaction between $Cross_listing$, $Post$, and the disclosure dummy variables are positive and significant, indicating that cross-listed firms tend to engage in green innovation if they are willing to adhere to the norms and litigation requirements of the host market and increase their green disclosure levels. If Hong Kong investors provide monitoring and initiate proposals on firms' green activities, increasing the level of green information disclosure may serve as a response to Hong Kong investors' monitoring.

We also construct a dummy variable for green punishments (awards) that equals 1 if firms suffer (do not obtain) environmental punishments (awards) before cross-listing but avoid (receive) such punishments (awards) after cross-listing and 0 otherwise ($Punishments$ and $Awards$). We interact $Cross_listing$, $Post$, and $Awards$ ($Punishments$) and reports the results in Table 7. The coefficients of the interaction between $Cross_listing$, $Post$, and $Awards$ ($Punishments$) are positive and significant, indicating that firms increase their green innovation engagement if they cater to foreign investors' expectations of green development, pay attention to environmental protection, and receive (avoid) environmental awards (punishments). In general, firms that adhere to green expectations and regulations in foreign countries are likely to engage in green innovation.

Finally, we assume that Hong Kong investors have a stronger effect on cross-listed firms' green activities when they hold a higher percentage of such firms' shares. In this scenario, Hong Kong investors are likely to suggest certain green activities and encourage firms to engage in green innovation. Accordingly, we introduce a ratio calculated as the number of shares held by Hong Kong investors scaled by the number of total shares (H_share) and interact $Cross_listing$, $Post$, and H_share . We include $Cross_listing \times Post \times H_share$ in Equation (1) and present the results in Table 8. The coefficients of $Cross_listing \times Post \times H_share$ are positive and significant, indicating that firms with a high percentage of shares held by Hong Kong investors are likely to be guided by Hong Kong investors and engage in green innovation.

4.6. Financing effect

Cross-listed firms have the advantage of extending their financing

Table 5

Effect of the time lag.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Applications</i> _{i,t}	<i>Applications</i> _{i,t-1}	<i>Applications</i> _{i,t-2}	<i>Grants</i> _{i,t-1}	<i>Grants</i> _{i,t-2}	<i>Grants</i> _{i,t-3}	<i>Citations</i> _{i,t-1}	<i>Citations</i> _{i,t-2}	<i>Citations</i> _{i,t-3}
	1	2	3						
(<i>Cross-listing*Post</i>) _{i,t}	0.196** (2.111)	0.169* (1.705)	0.190* (1.834)	0.148*** (3.871)	0.180*** (4.532)	0.183*** (4.386)	0.174*** (3.277)	0.141** (2.400)	0.165** (2.525)
Constant	-22.138*** (-18.971)	-21.119*** (-16.352)	-20.251*** (-14.988)	-19.586*** (-20.614)	-19.142*** (-19.611)	-17.485*** (-17.318)	-16.985*** (-14.152)	-16.621*** (-12.147)	-16.370*** (-12.021)
Industry and year fixed effects and controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pseudo R ²	0.767	0.771	0.767	0.652	0.659	0.664	0.667	0.679	0.680
Observations	3063	2749	2452	3063	2749	2452	3063	2749	2452

Note: In this table, the time lag effect are presented. The variables are defined in Sections 3 and 4.4. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 6

Stakeholders' pressure (information disclosure).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>CO2_disclosure</i>			<i>Reputation_disclosure</i>			<i>Environmentinv_disclosure</i>		
	<i>Applications</i>	<i>Grants</i>	<i>Citations</i>	<i>Applications</i>	<i>Grants</i>	<i>Citations</i>	<i>Applications</i>	<i>Grants</i>	<i>Citations</i>
<i>CO2_disclosure</i> _{i,t} / <i>Reputation_disclosure</i> _{i,t} / <i>Environmentinv_disclosure</i> _{i,t}	-0.926*** (-5.123)	-0.857*** (-4.950)	-0.644*** (-9.041)	-0.483*** (-5.697)	-0.638*** (-3.073)	-0.040 (-0.138)	-0.877*** (-5.818)	-0.330*** (-4.635)	-0.105* (-1.844)
(<i>Cross-listing*Post</i>) _{i,t}	0.029 (0.245)	0.023 (0.127)	0.208*** (3.678)	0.049 (1.424)	-0.002 (-0.021)	-0.545** (-2.397)	-0.073 (-1.296)	0.162*** (16.042)	-0.050*** (-3.215)
(<i>CO2_disclosure</i> _{i,t} / <i>Reputation_disclosure</i> _{i,t} / <i>Environmentinv_disclosure</i> _{i,t} * <i>Cross-listing*Post</i>) _{i,t}	0.873*** (4.063)	0.786*** (3.111)	0.598*** (6.570)	0.610*** (6.675)	0.794*** (3.504)	0.834** (2.238)	0.950*** (6.145)	0.314*** (4.394)	0.169*** (2.828)
Constant	-11.242*** (-21.563)	-13.835*** (-25.134)	-16.583*** (-78.651)	-18.490*** (-76.488)	-19.538*** (-21.868)	-26.220*** (-16.577)	-11.436*** (-22.096)	-20.122*** (-165.400)	-13.890*** (-89.001)
Industry and year fixed effects and controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pseudo R ²	0.638	0.656	0.646	0.621	0.636	0.824	0.638	0.799	0.668
Observations	3354	3354	3354	3354	3354	3354	3354	3354	3354

Note: In this table, the effects of stakeholder pressure (information disclosure) are presented. The variables are defined in Sections 3 and 4.5. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 7

Stakeholders' pressure (awards and punishments).

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Awards</i>			<i>Punishments</i>		
	<i>Applications</i>	<i>Grants</i>	<i>Citations</i>	<i>Applications</i>	<i>Grants</i>	<i>Citations</i>
<i>Awards</i> _{i,t} / <i>Punishments</i> _{i,t}	-0.481* (-1.897)	-0.628*** (-3.047)	-0.032 (-0.111)	0.063 (0.739)	0.143* (1.810)	0.031 (0.815)
(<i>Cross-listing*Post</i>) _{i,t}	-0.217 (-1.485)	-0.029 (-0.303)	-0.588*** (-2.615)	0.180*** (4.576)	0.166*** (4.296)	-0.036* (-1.799)
(<i>Awards/Punishments*Cross-listing*Post</i>) _{i,t}	0.827*** (2.820)	0.815*** (3.615)	0.872** (2.347)	0.802*** (2.716)	1.597*** (4.715)	0.447** (2.074)
Constant	-19.707*** (-20.430)	-19.537*** (-21.736)	-26.254*** (-16.623)	-18.502*** (-20.502)	-19.583*** (-21.830)	-8.562*** (-37.849)
Industry and year fixed effects and controls	yes	yes	yes	yes	yes	yes
Pseudo R ²	0.772	0.636	0.824	0.621	0.636	0.490
Observations	3354	3354	3354	3354	3354	3354

Note: In this table, the effect of stakeholder pressure (awards and punishments) is presented. The variables are defined in Sections 3 and 4.5. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

channels and raising capital in the foreign capital market (Bosco & Misani, 2016). This is especially the case when firms face a strict financing environment and pay relatively high financing costs in the domestic market. Cross-listing on foreign exchanges allows firms to receive low-cost capital, which helps them fund green innovation projects (Feng et al., 2022). In this subsection, we investigate whether firms increase their green innovation if they can receive low-cost financing in the Hong Kong market. Accordingly, we estimate firms' equity financing

costs using $Equity\ financing\ costs_{i,t} = \sqrt{EPS_{i,t+2} - EPS_{i,t+1}/P_{i,t}}$, where EPS is the predicted earnings per share, as suggested by Huo et al. (2012), and P is the year-end closing stock price (Meng et al., 2020). We construct a dummy variable that equals 1 if the equity financing cost in the Hong Kong market is lower than that in the A-share market and 0 otherwise (*Low_cost*), and we include the interaction between *Cross-listing*, *Post*, and *Low_cost* in Equation (1). The regression results in Panel A of Table 9 generally show the coefficients of *Cross_listing* × *Post* and of

Table 8
Stakeholders' pressure (percentage of H-shares).

	(1)	(2)	(3)
	Applications	Grants	Citations
$H_share_{i,t-1}$	44.017*** (3.423)	38.657*** (2.987)	-20.943 (-1.069)
$(Cross_listing*Post)_{i,t}$	6.514*** (3.000)	4.470** (2.045)	10.133*** (3.063)
$(H_share*Cross_listing*Post)_{i,t-1}$	14.229* (1.837)	15.185* (1.948)	-15.947 (-1.352)
Constant	-153.513*** (-19.198)	-152.920*** (-19.001)	-175.933*** (-14.445)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.616	0.612	0.550
Observations	3354	3354	3354

Note: In this table, the effect of stakeholder pressure (percentage of H-shares) is presented. The variables are defined in Sections 3 and 4.5. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 9
The financing effect.

Panel A	(1)	(2)	(3)
	Applications	Grants	Citations
$Low_cost_{i,t-1}$	-0.642*** (-3.418)	-0.518** (-2.166)	-0.386* (-1.684)
$(Cross_listing*Post)_{i,t}$	0.211*** (3.216)	0.218*** (3.056)	0.262*** (3.581)
$(Low_cost*Cross_listing*Post)_{i,t-1}$	0.707*** (3.519)	0.542** (2.140)	0.401* (1.654)
Constant	-23.223*** (-16.918)	-24.780*** (-18.187)	-20.224*** (-12.185)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.603	0.616	0.631
Observations	3354	3354	3354
Panel B	(1)	(2)	(3)
	Applications	Grants	Citations
$Financing_{i,t-1}$	-1.023*** (-15.881)	-0.897*** (-10.376)	-1.235*** (-30.702)
$(Cross_listing*Post)_{i,t}$	0.384*** (37.414)	0.098*** (6.379)	0.322*** (35.304)
$(Financing*Cross_listing*Post)_{i,t-1}$	4.460*** (12.194)	2.501*** (4.136)	6.930*** (24.172)
Constant	-27.351*** (-118.588)	-19.386*** (-77.318)	-30.113*** (-158.706)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.714	0.782	0.636
Observations	3354	3354	3354
Panel C	(1)	(2)	(3)
	Applications	Grants	Citations
$Equity_financing_{i,t-1}$	0.068 (0.270)	-0.454* (-1.743)	0.284 (0.993)
$(Cross_listing*Post)_{i,t}$	-0.051 (-1.281)	-0.030 (-0.777)	-0.022 (-0.427)
$(Equity_financing*Cross_listing*Post)_{i,t-1}$	118.006*** (4.097)	105.867*** (3.690)	109.004*** (2.933)
Constant	-10.023*** (-17.915)	-9.938*** (-18.115)	-10.059*** (-14.590)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.366	0.374	0.376
Observations	3354	3354	3354

Note: In this table, the financing effect is presented. The variables are defined in Sections 3 and 4.6. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

the interaction between *Cross_listing*, *Post*, and *Low_cost* to be positive and significant, indicating that cross-listed firms that receive low-cost financing resources in the Hong Kong market have a financing advantage when it comes to investing in green innovation; thus, these firms increase their investment in green innovation after cross-listing. We further calculate the ratio of total funds received via equity, bond, and bank financing to total assets in a year (*Financing*) and the ratio of funds received by issuing equity to total assets in a year (*Equity_financing*). We include the interaction between *Cross_listing*, *Post*, and *Financing* (*Equity_financing*) in Equation (1). The coefficient of *Cross_listing* × *Post* × *Financing* (*Cross_listing* × *Post* × *Equity_financing*) is positive and significant, indicating that firms that receive more external financing after cross-listing have more patent applications (grants and citations). In Panels B and C of Table 9, respectively, the coefficients of *Cross_listing* × *Post* × *Financing* and *Cross_listing* × *Post* × *Equity_financing* are positive and significant, suggesting that cross-listed firms with high levels of external financing tend to increase their green innovation after cross-listing, and cross-listing serves as a means of enhancing green innovation.

4.7. Stock price informativeness

Studies demonstrate that investors in developed markets are sophisticated in analyzing and trading information, which increases the information component embedded in stock prices after cross-listing (e. g., *Bris et al., 2012*). The widespread acceptance of green development by consumers and investors in developed markets leads them to pursue green products and green assets. This preference for green innovation is also reflected by stock prices and may be captured by the managers of cross-listed firms (*Zhang et al., 2021*). These managers may in turn learn from such informative stock prices and accept investors' beliefs about green development, leading them to invest in green innovation activities and generate more green patents (*Abdallah & Abdallah, 2019; Ghadhab & Hellara, 2016*).

In this subsection, we test this argument and investigate whether stock price informativeness serves as a possible mechanism through which cross-listing facilitates green innovation. We first estimate stock price informativeness by adopting the stock return synchronicity method (*Li et al., 2015*). We conduct the following regression to estimate synchronicity:

$$R_{i,t} = \beta_1 + \sum_{l=0}^3 \beta_{1l} R_{g,t-l} + \sum_{r=0}^3 \beta_{2r} R_{m,t-r} + \delta_{it} \quad (2)$$

where $R_{i,t}$ indicates the stock return of firm i on day t for either A-shares or H-shares. R_g reflects the daily return of the global market portfolio, and R_m represents the daily return of the A-share index for A-shares and the daily return of the Hang Seng index for H-shares (*Li et al., 2015*). We abstract the coefficient of determination (R_{it}^2) from Equation (2) and define synchronicity as $\ln(R_{it}^2 / (1 - R_{it}^2))$ (*Li et al., 2015*). The high synchronicity measure indicates that the stock return of a firm is largely explained by the return of the market index and is mainly driven by market information rather than firm-specific information. Therefore, stock returns do not fully reflect firm-specific information and are not informative. Accordingly, for the purpose of explanation, we calculate the informativeness measure as $1 - \ln(R_{it}^2 / (1 - R_{it}^2))$ (*Informativeness*), in which a high value indicates high stock price informativeness.

Next, we calculate the difference between the informativeness of H-shares and that of A-shares (*Dif_informativeness*) and introduce a dummy variable that equals 1 when *Dif_informativeness* is positive and 0 otherwise (*Informative_Hshare*), indicating that H-shares incorporate more firm-specific information than A-shares when *Informative_Hshare* equals 1. *Informative_Hshare* equals 0 for non-cross-listed firms. Finally, we construct an interaction between *Cross_listing*, *Post*, and

Informative_Hshare and include this interaction in Equation (1).

The regression results in Table 10 generally show the coefficients of the interaction between *Cross_listing* and *Post* to be positive and significant, suggesting an increase in cross-listed firms' green innovation after cross-listing. The coefficients of the interaction between *Cross_listing*, *Post*, and *Informative_Hshare* are also positive and significant, suggesting that cross-listed firms with an informative H-share price engage more in green innovation after cross-listing than other cross-listed and non-cross-listed firms. This result supports the argument that cross-listed firms learn from their informative H-share prices, which may reflect investors' preferences for green development. Therefore, cross-listed firms increase their green innovation to follow investors' green tendencies (Abdallah & Abdallah, 2019; Ghadhab & Hellara, 2016). In general, increased stock price informativeness can explain the positive relationship between cross-listing and green innovation.

4.8. Environmental and financial performance

We demonstrate that cross-listed firms tend to increase their green innovation investment and generate more green innovation products after cross-listing. In this subsection, we investigate whether green innovation enables cross-listed firms to improve their ability to save energy and protect the environment (environmental performance) and whether firms can transform enhanced environmental performance into financial benefits.

Accordingly, we estimate environmental performance using principal component analysis (PCA). The variables adopted to conduct the PCA include the volume of pollution reduction, the volume of waste reduction, the volume of recycling, the volume of resource consumption reduction, and the amount of environmental accident reduction (Muisyo & Qin, 2021). The first component of the PCA is used as a proxy for environmental performance (*En_performance*). Financial performance is measured using return on equity (ROE, defined as earnings before interest and taxes/total equity) and Tobin's Q (Q, defined as the market value of equity plus the book value of total debt scaled by the book value of total assets.) (Chen & Ma, 2021). For the purpose of explanation, ROE and Q are multiplied by 100. We also construct interactions between *Cross_listing*, *Post*, and green patent proxies in Section 3.2 and regress *En_performance* (ROE and Q) on these interactions. The control variables include firm size (*Size*), financial leverage (*Leverage*), the fixed asset ratio (*Fix_assets*), the number of independent directors divided by the number of board members (*Independent*), the sum of the square of shares held by the top five major shareholders scaled by the number of total shares (*Top5*), and the number of shares held by the largest shareholder scaled by the number of total shares (*Top1*) (Chen & Ma, 2021).

The regression results in Tables 11 and 12 generally show the

Table 10
Stock price informativeness.

	(1) Applications	(2) Grants	(3) Citations
<i>Informative_Hshare</i> _{i,t}	−0.253*** (−3.862)	−0.340*** (−5.196)	−0.254*** (−4.974)
(<i>Cross_listing</i> * <i>Post</i>) _{i,t}	−0.024 (−0.771)	0.330*** (22.359)	0.084** (2.353)
(<i>Informative_Hshare</i> * <i>Cross_listing</i> * <i>Post</i>) _{i,t}	0.258*** (3.579)	0.239*** (3.580)	0.138** (2.251)
Constant	−11.246*** (−78.162)	−22.442*** (−160.441)	−12.687*** (−90.334)
Industry and year fixed effects and controls	yes	yes	yes
Pseudo R ²	0.637	0.781	0.672
Observations	3354	3354	3354

Note: In this table, the results of stock price informativeness are presented. The variables are defined in Sections 3 and 4.7. The control variables are consistent with those in Table 2. The Poisson regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 11
Environmental performance.

	(1) Applications	(3) Grants	(5) Citations
<i>Applications</i> _{i,t-1} / <i>Grants</i> _{i,t-1} / <i>Citations</i> _{i,t-1}	−0.057** (−2.553)	−0.050* (−1.794)	0.005 (1.380)
(<i>Cross_listing</i> * <i>Post</i>) _{i,t}	0.844** (2.485)	0.729 (1.319)	0.913* (1.851)
(<i>Applications</i> / <i>Grants</i> / <i>Citations</i> * <i>Cross_listing</i> * <i>Post</i>) _{i,t-1}	0.076* (1.714)	0.087* (1.707)	−0.006 (−1.605)
Constant	−5.307** (−1.974)	−7.439 (−1.553)	−6.400 (−1.645)
Industry and year fixed effects and controls	yes	yes	yes
R ²	0.440	0.377	0.067
Observations	3354	3354	3354

Note: In this table, the effect of green innovation on environmental performance is presented. The variables are defined in Sections 3 and 4.8. The fixed-effect regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

coefficients of the interaction between *Cross_listing*, *Post*, and *Applications* (Grants and *Citations*) to be positive and significant, indicating an increase in cross-listed firms' financial and environmental performance if they generate more high-quality green innovation products after cross-listing. High-quality green innovation products enable firms to improve their energy efficiency and environmental protection level, which contributes to their reputation and competitive advantage and ultimately improves firm performance. That is, firms demonstrate high environmental and financial performance when they engage in green innovation after cross-listing.

5. Conclusion

Green innovation enables firms to improve their energy efficiency and maintain sustainable growth. However, firm managers may be averse to it given the cost and risk involved. Therefore, it is still controversial whether firms are willing to engage in green innovation. In this study, we investigate whether cross-listed firms increase their green innovation and generate high-quality green innovation products after cross-listing. The analysis results indicate that cross-listed firms file more green patent applications, are granted more green patents, and receive more citations than non-cross-listed firms. The transmission mechanisms suggest that cross-listed firms that follow foreign investors' expectations of sustainable growth tend to increase their level of green disclosure and engage in green innovation. Stock price informativeness improves after cross-listing, which enables stock prices to reflect investors' green tendencies and guide cross-listed firms to engage in green innovation. Furthermore, high-quality firms can receive capital at low costs in the Hong Kong market, representing a financing advantage of investing in green innovation. In terms of firm performance, green innovation contributes to firms' green innovation performance and allows them to save energy and improve their image, which ultimately benefits their financial performance.

The results of this study have several implications. First, as environmental problems and climate change become increasingly urgent, it is necessary for society to encourage firms to adopt green production and sustainable development strategies. We demonstrate that firms tend to follow the expectations of stakeholders in society to improve their reputation. Therefore, stakeholders' (e.g., investors and customers) positive attitudes toward green innovation investment and green growth may be crucial in motivating firms to adopt green strategies. Second, financing is a crucial factor affecting firms' green innovation decisions. Low-cost financing can facilitate firms' investment in long-term risky green innovation. Accordingly, it is necessary to enhance information disclosure and corporate governance requirements and to introduce advanced trading regulations (e.g., short selling), as they can improve

Table 12
Financial performance.

	(1)	(2)	(3)	(4)	(5)	(6)
	Applications		Grants		Citations	
	ROE	Q	ROE	Q	ROE	Q
$Applications_{i,t-1}/Grants_{i,t-1}/Citations_{i,t-1}$	−0.048 (−1.233)	−1.293 (−1.588)	−0.009 (−0.906)	−0.975* (−1.801)	0.077 (0.804)	−0.130 (−0.203)
$(Cross-listing*Post)_{i,t}$	−2.566*** (−3.146)	−11.452 (−1.634)	−2.079*** (−2.582)	−5.063 (−1.198)	−1.652** (−2.334)	−5.124 (−1.222)
$(Applications/Grants/Citations*Cross-listing*Post)_{i,t-1}$	0.489*** (3.040)	2.274** (2.045)	0.395** (2.017)	0.019* (1.945)	0.757* (1.857)	0.019*** (5.042)
Constant	−44.015*** (−4.956)	566.318*** (5.948)	−43.024*** (−4.933)	517.183*** (9.243)	−42.618*** (−4.910)	544.639*** (10.371)
Industry and year fixed effects and controls	yes	yes	yes	yes	yes	yes
R ²	0.110	0.278	0.109	0.322	0.112	0.322
Observations	3354	3354	3354	3354	3354	3354

Note: In this table, the effect of green innovation on financial performance is presented. The variables are defined in Sections 3 and 4.8. The fixed-effects regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

capital market efficiency and enable high-quality firms to receive low-cost funds. This can be an effective way to encourage firms' green innovation. Third, green innovation can improve firms' green performance and enable them to avoid environmental-related punishments. Green innovation can also decrease firms' production costs and save energy, ultimately contributing to their financial performance. In general, although green innovation is costly and risky, it serves as a long-

term contribution to firms' profitability and competitiveness.

CRediT authorship contribution statement

Xin Xiang: Conceived and designed the analysis, Collected the data, Contributed data or analysis tools, Wrote the paper. **Xu He:** Contributed data or analysis tools, Performed the analysis, Wrote the paper.

Appendix

Table A1
Univariate tests of covariate balance

Variables		Number of observations	Number of firms	Treatment mean	Control mean	Standardized difference	T-statistics
<i>Applications</i>	Unmatched sample	42,392	4865	16.275	1.484	0.764	46.100***
	Matched sample	3651	223	16.275	17.127	−0.008	−0.463
<i>Grants</i>	Unmatched sample	42,392	4865	15.458	2.985	0.738	43.479***
	Matched sample	3651	223	15.458	17.648	−0.019	−1.136
<i>Citations</i>	Unmatched sample	42,392	4865	19.607	3.060	0.671	41.156***
	Matched sample	3651	223	19.607	22.825	−0.014	−0.923
<i>Size</i>	Unmatched sample	42,392	4865	23.461	21.985	1.721	47.409***
	Matched sample	3651	223	23.461	23.456	0.006	0.145
<i>Leverage</i>	Unmatched sample	42,392	4865	0.546	0.420	0.803	22.255***
	Matched sample	3651	223	0.546	0.543	0.019	0.360
<i>ROA</i>	Unmatched sample	42,392	4865	0.025	0.032	−0.166	−7.252***
	Matched sample	3651	223	0.025	0.025	0.036	0.062
<i>R&D</i>	Unmatched sample	42,392	4865	0.001	0.002	−0.181	−5.531***
	Matched sample	3651	223	0.001	0.001	0	0.000
<i>Fix_assets</i>	Unmatched sample	42,392	4865	0.259	0.202	0.451	13.902***
	Matched	3651	223	0.259	0.257	0.002	0.341
<i>Capital_exp</i>	Unmatched sample	42,392	4865	0.053	0.047	0.222	5.367***
	Matched sample	3651	223	0.053	0.051	0.049	1.101
<i>Age</i>	Unmatched sample	42,392	4865	17.498	17.611	0.044	−0.603
	Matched	3651	223	17.498	17.221	0.110	1.413
<i>Q</i>	Unmatched sample	42,392	4865	1.348	1.892	−0.759	−23.174***
	Matched sample	3651	223	1.348	1.517	−0.171	−6.882***

Note: This table presents the results of the comparison between treatment means and control means in terms of matching variables. The last two columns show the standardized differences in the covariate mean and the T-statistics of these mean differences, respectively. ***p < 0.01, **p < 0.05, *p < 0.1.

Table A2
Multivariate tests of covariate balance

	(1)	(2)
	Unmatched sample	Matched sample
$Applications_{i,t}$	−0.022* (−1.942)	−0.000 (−0.158)
$Grants_{i,t}$	0.003	0.000

(continued on next page)

Table A2 (continued)

	(1)	(2)
	Unmatched sample	Matched sample
<i>Citations</i> _{i,t}	(0.259) 0.045*** (3.870)	(0.125) –0.002 (–1.568)
<i>Size</i> _{i,t}	0.669*** (28.941)	–0.325*** (–11.128)
<i>Age</i> _{i,t}	0.010*** (2.919)	0.000 (0.095)
<i>Leverage</i> _{i,t}	–0.160 (–0.902)	0.205 (0.991)
<i>Fix_assets</i> _{i,t}	0.315* (1.691)	0.082 (0.465)
<i>Capital_exp</i> _{i,t}	–0.406 (–0.969)	–0.284 (–0.492)
<i>ROA</i> _{i,t}	–1.635*** (–2.918)	0.808 (1.070)
<i>R&D</i> _{i,t}	–11.311*** (–3.526)	2.606 (0.528)
<i>Q</i> _{i,t}	0.020 (0.662)	0.000 (0.008)
Constant	–17.344*** (–34.251)	7.810*** (11.661)
Industry and year fixed effects	yes	yes
Pseudo R ²	0.387	0.100
Observations	30,597	3623

Note: This table presents the probit regression results that compare the matching characteristics in treated firms with those in control firms. The dependent variable in columns (1) and (2) is Cross-listing mentioned in Section 3.3. Independent variables include all matching variables defined in Section 3.5. The regression results in columns (1) and (2) are estimated based on unmatched and matched samples, respectively. The probit regression method is used. Robust z-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

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