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# DOES CAPITAL MARKET OPENING PROMOTE ENTERPRISE GREEN INNOVATION? EVIDENCE FROM SHANGHAI-HONG KONG STOCK CONNECT AND SHENZHEN-HONG KONG STOCK CONNECT

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**Abstract.** This study selects Chinese A-share listed enterprises from 2010 to 2020 as the research sample, constructs a Difference-in-differences model to analyze the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy on enterprise green innovation. The transmission channels are tested, and the heterogeneity of this impact is further explored. It is found that the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy has significantly improved the total level, quality and quantity of enterprise green innovation, and the effect on the total level and quality is greater than the quantity. The Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy can effectively alleviate the financing constraints faced by enterprises, improve the information environment of enterprises, and thus improve their green innovation. There is heterogeneity in the nature of property rights, corporate social responsibility, industry monopoly and regional marketization in the promotion of enterprise green innovation by the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy.

**Keywords:** capital market opening, enterprise green innovation, financing constraint, information environment.

**JEL Classification:** G15, G38, O32.

## Introduction

With the increasing concerns of global environmental pollution and resource shortage, global climate change and environmental degradation have become the two major challenges faced by the humanity (Beck, 2010; Lyu et al., 2023). The economic growth model at the cost of the environment has become unsustainable, and how to relieve the tension between economic development and environmental protection has become urgent for all countries (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). The current view widely recognized by

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the government and the public is that green innovation is an important means to break the national resource constraint and accelerate the transformation of economic development mode (Schiederig et al., 2012). Therefore, green innovation has become a necessary path for the countries to pursue sustainable competitive advantages (Cooke, 2012; Li & Huang, 2017). In recent years, China had rapid economic development, but due to its backward concept of green development and weak capacity of green innovation, it has brought great burden to the ecological environment and become the world's top ranking carbon emitting country (Zhu et al., 2020). In order to improve this situation, China has set a clear target of "carbon peak by 2030 and carbon neutral by 2060", and has inspired enterprises to shift their innovation activities to green technologies (Zhang et al., 2022). This will certainly accelerate the adjustment and capability improvement of industries in strategy, business and product dimensions around green transformation. For enterprises, green innovation can not only reduce costs, decrease energy consumption, and achieve a balance between obtaining economic benefits and environmental protection, but also enhance the market competitiveness of their products, strengthen their competitive advantages, and achieve sustainable development (Dangelico & Pujari, 2010; Lyu et al., 2022). Therefore, under the goal of carbon neutrality, enterprise green innovation is of great significance to achieve the dual tasks of environmental protection and economic development, and how to improve the level of enterprise green innovation has become an urgent issue to be solved (Tolliver et al., 2021).

The degree of capital market opening is a key indicator for a country's economic development, as well as an important initiative to promote the reform of financial system and healthy growth of the capital market (Chinn & Ito, 2006). In November 2014 and December 2016, the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy were opened in China, and we usually abbreviate them as the Shanghai Shenzhen stock connect (SSSC) policy. Investors from all over the world can invest in enterprises listed on China's Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) through the Hong Kong Stock Exchange (HKSE). The originally relatively closed Chinese A-share market began to link up with the world capital market. Compared with the previous one-way opening policies such as Qualified Foreign Investors (QFII) and Renminbi Qualified Foreign Investors (RQFII), the two-way opening policy represented by the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy has further relaxed the access criteria for investors and taken a big step forward in opening China's capital market. In 2020, the share of foreign holdings in A-shares through SSSC was 3.64%, which is 20 times the share of inflows through QFII and RQFII. The participation of foreign investors in the Chinese A-share market is increasing. For enterprise, green innovation can help them gain competitive advantages, and increase the long-term value (Song & Yu, 2018). Therefore, the "value investment" tendency of foreign investors introduced by the capital market opening may also have some influence on the green innovation of enterprises.

Study on the effects of capital market opening has increased significantly in recent years. At the macro level, capital market opening provides a benign competitive environment, prompting regulatory authorities to introduce a series of supporting policies to smooth stock market operations (Errunza & Miller, 2000). As a result, the risk of stock price collapse is decreased and the efficiency of stock pricing is increased (Kacperczyk et al., 2021). Both capital

accumulation and total factor productivity are significantly boosted (Bekaert et al., 2011). Capital market opening also exacerbates cross-border risk contagion between economies and international markets. Systemic financial risks may be triggered and the real economy may be negatively affected (Stiglitz, 2004). Foreign investors who adopt a blind investment strategy and frequent market trading may increase market volatility (Bae et al., 2004; Xu et al., 2020). At the micro level, firm behavior may be significantly influenced by capital market opening. First, international institutional investors tend to have more market information (Akins et al., 2012), which is beneficial for improving enterprise' investment efficiency and profitability (Peng et al., 2021; Mitton, 2006). Second, the opening of capital market contributes to a greater substance of stock price information and a stronger directing function for stock prices in resource allocation. Enterprises' business behavior and financing decisions will be influenced (Li et al., 2022). In addition, capital market opening is conducive to the introduction of foreign investors with rich governance experience. They alleviate agency problems in information asymmetry by developing long-term corporate strategies and strengthening external corporate oversight (Bae et al., 2012; Kim & Cheong, 2015). Therefore, enterprises' innovation capacity (Luong et al., 2017) and governance capacity (Ferreira & Matos, 2008) are improved.

From the impact of capital market opening on green innovation, it achieves the interconnection of capital markets and enabled enterprises to gain more investors' attention (Lang et al., 2003). Enterprises' financing constraints are eased and green innovation is further stimulated, which in turn leads to a remarkable increase in the quantity and quality of green innovation (Fiorillo et al., 2022). The foreign institutional investors introduced by capital market opening also bring green technologies and advanced management experience. They help to enhance enterprises' environmental governance efficiency, improve their environmental performance, and push the development of Chinese enterprises in a green direction (Guoyou et al., 2013; Dyck et al., 2019). Meanwhile, capital market opening raises the quality of stock market environmental disclosure, and enhances the ESG performance of underlying stocks (Deng et al., 2022). It plays an active role in enhancing enterprise awareness of social responsibility strategic and the level of CSR (Yang et al., 2022), thus promote enterprise green innovation by raising enterprise environmental awareness and alleviating information asymmetry (Zhang et al., 2021; Sha et al., 2022).

There are still some issues that need to be addressed although the rich and fascinating existing research. First, from the standpoint of enterprise green innovation, few studies have addressed the economic consequences and policy implications of capital market opening. Most of the studies have concerned the impact of capital market opening on enterprise share prices, investment efficiency and corporate governance. Some of the studies have confirmed the effects of capital market opening to corporate social responsibility and ESG performance, but there are few studies based on the perspective of green innovation. However, innovation capability and pollution governance level are also important considerations for foreign investors. Especially considering the investment risk and enterprise development potential, foreign investors may prefer green investments. Second, the effects of capital market opening on various forms of green innovation have not been taken into account in previous studies. Although there have been few studies that examine the impact of capital market opening on

green innovation from a green patent perspective (Sha et al., 2022), the impact of capital market opening on various forms of green innovation may differ due to the obvious differences in the innovation level and protection scope of various green patents forms. Third, existing studies are ambiguous about the channels by which opening up capital markets affects enterprise green innovation. The channels of corporate financing constraints and information environment may be overlooked.

The following are some potential contributions of this study. First, based on theoretical analysis, this study examines the relationship between capital market opening and enterprise green innovation, further support the empirical evidence on the economic effects of capital market opening. Second, the green innovation is classified into total level, quality and quantity, and heterogeneity analysis was further performed. Third, the channels of the role of financing constraints and information environment in the effect of capital market opening on enterprise green innovation are discussed and verified, which helps to improve the precision of policy implementation.

## 1. Theoretical analysis and research hypothesis

### 1.1. Direct effect

The successful implementation of enterprise green innovation requires subjective awareness and objective financial assurance. In terms of the subjective awareness, capital market opening has increased their attention to green innovation. First, foreign investors are more concerned with company sustainability and environmental preservation than local investors. For instance, fund managers from wealthy nations frequently consider environmental considerations when creating their portfolios (Jagannathan et al., 2017). Second, compared to individual investors, the institutional investors introduced by capital market opening are more mature in their investment philosophy and have a preference for green innovative enterprises (Palacios-González & Chamorro-Mera, 2018). They tend to construct long-term portfolios, and enterprises with higher green innovation capabilities appear to earn higher quantitative investment returns in the long term (Edmans, 2011). Therefore, in the context of "carbon peak" and SSSC policy, foreign investors prefer to invest in enterprises with high green innovation capacity, both from their own benefit and from policy orientation. Under this premise, enterprises need to place more emphasis on green innovation and improve their green innovation capability if they want to get long-term favor from investors.

In terms of objective financial assurance, capital market opening provides companies with the financial assurance to conduct green innovation activities. Enterprise green innovation activities are a long-cycle and uncertain process (Xiang et al., 2022), which requires timely, adequate and continuous financial investment to guarantee the operation of the whole process. This need cannot be met by the companies' own funds alone, so they need to seek external financing (Brown et al., 2009). External financing mainly includes indirect financing based on banks and direct financing based on capital markets. Compared to capital markets, commercial banks are less willing to support enterprise green innovation. Most of the assets of innovative enterprises are intangible assets that are difficult to value, such as patents and intellectual property, and cannot provide banks with sufficient collateral (Lindman &

Söderholm, 2016). Investors with various risk and maturity preferences and maturity in the capital market are sufficient to meet the funding needs of enterprise green innovations (Hsu et al., 2014). Enterprises gain financing to support their green innovation through capital market opening. To gain this financial support in the long term, they need to enhance their own capacity for green innovation capabilities, which creates a virtuous circle. On this basis, the following hypothesis is proposed.

Hypothesis 1: Capital market opening can significantly enhance enterprise green innovation.

## 1.2. Transmission channels

### 1.2.1. Financing constraints

Due to its high sunk cost, long cycle and high risk, the green innovation activities of enterprises are prone to financing constraints and are in urgent need of external financial support (Chen et al., 2021). The large amount of foreign capital brought by capital market opening has greatly facilitated equity financing for enterprises and eased their financing constraints (Laeven, 2003). This provided a solid material basis to engage in green innovation activities. On the one hand, foreign investors often have a more rational investment structure and stronger risk-taking ability, and will focus more on the long-term business behavior and sustainability of companies (Bena et al., 2017). They are more tolerant of innovation failures and are willing to provide financial support to green and innovative companies. On the other hand, foreign investors who have more international network resources and resource integration capabilities can quickly raise funds for enterprise green innovation activities (Reddy, 1997), thus reducing enterprise financing costs. At the same time, companies favored by foreign investors will convey to the outside world the information of high development potential and satisfactory governance system (Liu et al., 2014). This will increase the influence of foreign investors' trading behavior on enterprises and alleviate their financing constraints to a greater extent. On this basis, the following hypothesis is proposed.

Hypothesis 2: Capital market opening can increase enterprise green innovation by alleviating financing constraints.

### 1.2.2. Information environment

Enterprise green innovation activities usually suffer from information asymmetry (Lai et al., 2022). Enterprises have more information about green innovation projects than outside investors. However, they are often reluctant to disclose it to outsiders for fear competitor imitation. This makes external investors insufficiently informed about the green innovation projects they invest in, but capital market opening can make the information environment better and reduce information asymmetry (Liang et al., 2012). On the one hand, the SSSC policy has made the disclosure of enterprise information more transparent. For example, the SSE and SZSE clearly point out that the underlying companies should "pay attention to and adapt to changes in the external environment, further standardize information disclosure and strengthen investor relations management", which sets higher information disclosure requirements for companies entering the SSSC list. Moreover, the majority of foreign investors

introduced by capital market opening are institutional investors, who have richer resource networks and more professional analytical skills. They are better able to play the role of supervisors so that the quality of enterprise information disclosure can be improved (Bird & Karolyi, 2016). On the other hand, the underlying companies of SSSC policy often attract more analysts (Lang et al., 2003; Fernandes & Ferreira, 2008). As a link between investors and listed companies, analysts play the dual role of information search and interpretation, and can give full play to their professional expertise to improve the information environment. Through information collection of companies, they objectively convey the analysis results to investors (Jensen & Meckling, 2019). This not only allows investors to gain a fuller understanding of enterprise green innovation activities, but also gives companies more incentive to innovate green to attract long-term investors. On this basis, the following hypothesis is proposed.

Hypothesis 3: Capital market opening can increase enterprise green innovation by improving information environment.

## 2. Models and variables

### 2.1. Econometric models

The Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy were launched on November 17, 2014, and December 5, 2016, respectively, to further raise the level of capital market opening. The implementation of this policy follows the basic principle of "expansion in batches and dynamic management" and has grown into the primary means of foreign capital's participation in the A-share market. We consider this policy as a "quasi-natural experiment" and adopt Difference-in-differences (DID) model to identify the effect of capital market opening on enterprise green innovation in the study period of 2010–2020, which is four years before and after the implementation of the policy. Group dummy variables equal 1 for the firm listed in SSSC while 0 otherwise, and time dummy variables equal 1 for the year after the policy occurs while 0 otherwise. The model is constructed as follows:

$$Patent_{it} = \beta_0 + \beta_1 treat_i \times post_t + \beta_2 Control + \Sigma Industry + \Sigma Year + \varepsilon_{it}, \quad (1)$$

where $Patent_{it}$ denotes green innovation of firm $i$ at year $t$. $treat_i \times post_t$ denotes the core explanatory variable SSSC policy, which is the interaction term of group dummy variable and time dummy variable. *Control* is a set of control variables. $\beta_0$ are the intercept terms. $\beta_1$ is estimated coefficients of the core explanatory variables, reflecting the effect of SSSC on enterprise green innovation. $\beta_2$ is estimated coefficients of control variables. $\Sigma Industry$ and $\Sigma Year$ are industry fixed effects and year fixed effects. $\varepsilon_{it}$ is the random error term.

### 2.2. Variables

#### 2.2.1. Explained variable

Enterprise green innovation (*Patent*). Compared to the number of green patents awarded, the number of green patent applications eliminates external uncertainties like the effective-

ness and preferred kinds of patent application institutions, and the status of enterprise green innovation may be better portrayed (Yang et al., 2021). In light of Brunnermeier and Cohen (2003), the natural logarithm of the number of green patent applications is used to measure the total level of green innovation in an enterprise (*Total*). Green innovation patents comprise both green invention patents and green utility patents, with green invention patents having a higher level of innovation than green utility patents (Zhang et al., 2019). Therefore, the natural logarithm of the number of green utility patent applications is used to measure the quantity of enterprise green innovation (*Quan*), and the natural logarithm of the number of green invention patent applications is used to measure the quality of green innovation (*Qual*).

#### 2.2.2. Explanatory variable

The SSSC policy ($treat_i \times post_t$). The double difference term is used. $treat_i \times post_t$ equals 1 for the enterprises listed in SSSC and in the post period while 0 otherwise.

#### 2.2.3. Transmission channel variables

(1) Financing constraints (*KZ*). Based on Kaplan and Zingales (1997), the KZ index is constructed to estimate the degree of financing constraints faced by enterprises. It contains several financial indicators that provide a comprehensive measure of financing constraints. First, the enterprise's net cash flow from operations/total assets at the beginning of the year ($Cashflow_{it}/Asset_{it}$), cash dividends/total assets at the beginning of the year ($Div_{it}/Asset_{it}$), cash holdings/total assets at the beginning of the year ($Cash_{it}/Asset_{it-1}$), gearing ratio ($Lev_{it}$), and Tobin's Q value ($TobinQ_{it}$) are classified for each year. If $Cashflow_{it}/Asset_{it}$ below the median, $KZ_1$ is taken as 1, otherwise 0; if $Div_{it}/Asset_{it}$ below the median, $KZ_2$ is taken as 1, otherwise 0; if $Cash_{it}/Asset_{it-1}$ below the median, $KZ_3$ is taken as 1, otherwise 0; if $Lev_{it}$ above the median, $KZ_4$ is taken as 1, otherwise 0; if $TobinQ_{it}$ above the median, $KZ_5$ is taken as 1, otherwise 0. Second, the five sub-indicators are summed to calculate the total indicator.

$$KZ = KZ_1 + KZ_2 + KZ_3 + KZ_4 + KZ_5. \tag{2}$$

Then, the regression was performed using Ordered Logistic Regression (ORL) with $Cashflow_{it}/Asset_{it}$, $Div_{it}/Asset_{it}$, $Cash_{it}/Asset_{it-1}$, $Lev_{it}$ and $TobinQ_{it}$ as the independent variable and *KZ* as the dependent variable to estimate the regression coefficient values of each variable.

$$KZ_{it} = \alpha_1 \times Cashflow_{it}/Asset_{it} + \alpha_2 \times Div_{it}/Asset_{it} + \alpha_3 \times Cash_{it}/Asset_{it-1} + \alpha_4 \times Lev_{it} + \alpha_5 \times TobinQ_{it}. \tag{3}$$

Finally, the regression coefficients are multiplied with each sample independent variable to calculate the *KZ* index for each company for each year. It is generally believed that a higher value of *KZ* index indicates a higher degree of financing constraints faced by the company.

(2) Information environment (*Analyst*). The natural logarithm of the number of analysts tracked by the firm during the year is used to indicate analyst concerns and as a proxy for the enterprise's information environment. A higher number of analysts tracking indicates a higher level of analyst attention and a more transparent information environment for the enterprise (Harford et al., 2019).

### 2.2.4. Control variables

Referring to the existing literature, the control variables were selected from three aspects: firm fundamentals, financial status and governance characteristics. These include firm size (*Size*), years of listing (*ListAge*), whether state-owned enterprise (*SOE*); return on assets (*ROA*), cashflow ratio (*Cashflow*), gearing ratio (*Lev*), Tobin's Q value (*TobinQ*), percentage of top shareholder ownership (*Top1*), percentage of independent directors (*Indep*), and whether dual position (*Dual*). *Size* is expressed as the natural logarithm of annual total assets; *SOE* is 1 for China-owned holding enterprise and 0 for others; *ROA* is expressed as the ratio of net profit and average balance of total assets; *Cashflow* is expressed as the ratio of net cash flow from operating activities and total assets; *Lev* is expressed as the ratio of total liabilities and total assets at the end of the year; *TobinQ* is expressed as the ratio of enterprise book value and total assets, and enterprise book value is calculated by market value of outstanding shares + number of non-marketable shares × net assets per share + book value of liabilities; *Top1* is expressed as the ratio of the number of shares held by the largest shareholder to the total number of shares; *Indep* is expressed as the ratio of independent directors to the number of directors; *Dual* in which the chairman and CEO are the same person is 1, otherwise is 0.

Chinese A-share listed enterprises are the research sample in this study, and the study period is from 2010 to 2020. The CSMAR and Wind databases provided all of the original data. The sample was screened using the following criteria in order to make it representative. (1) Take financial companies and samples with missing data values out. (2) Remove observed samples from the analysis if the sample period's financial data were anomalous. (3) Excluding the sample of enterprises that were transferred in and then transferred out of the SSSC after the first batch, and those that were transferred into the SSSC after the first batch. (4) Excluding the sample of enterprises cross-listed on both the SSE and the HKSE (A + H); (5) Excluding the sample of enterprises listed in the year when the SSSC policy was implemented. (6) Winsorize the data at the 1% and 99% levels to control for the potential effect of outliers. The final 14645 observations were obtained, and Table 1 reports the statistical description of variables.

Table 1. Statistical description of variables

| Variable | Definition | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|---|
| *LnTotal* | Total green patent applications | 14645 | 0.900 | 1.193 | 0.000 | 4.718 |
| *LnQual* | Green invention patent applications | 14645 | 0.617 | 0.982 | 0.000 | 4.248 |
| *LnQuan* | Green utility patent applications | 14645 | 0.596 | 0.946 | 0.000 | 3.850 |
| *treat×post* | The SSSC policy | 14645 | 0.298 | 0.457 | 0.000 | 1.000 |
| *Size* | Firm size | 14645 | 22.200 | 1.300 | 19.620 | 25.970 |
| *ListAge* | Years of listing | 14645 | 2.279 | 0.748 | 0.693 | 3.296 |
| *Lev* | Gearing ratio | 14645 | 0.438 | 0.207 | 0.057 | 0.924 |
| *ROA* | Return on assets | 14645 | 0.036 | 0.062 | –0.247 | 0.206 |
| *Cashflow* | Cashflow ratio | 14645 | 0.045 | 0.068 | –0.158 | 0.241 |
| *Indep* | Percentage of independent directors | 14645 | 0.374 | 0.052 | 0.333 | 0.571 |

*End of Table 1*

| Variable | Definition | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|---|
| *Dual* | Whether dual position | 14645 | 0.254 | 0.435 | 0.000 | 1.000 |
| *TobinQ* | Tobin's Q value | 14645 | 2.047 | 1.397 | 0.850 | 9.448 |
| *SOE* | Whether state-owned enterprise | 14645 | 0.395 | 0.489 | 0.000 | 1.000 |
| *Top1* | Percentage of top shareholder ownership | 14645 | 0.339 | 0.145 | 0.084 | 0.719 |
| *KZ* | Financing constraints | 14645 | 1.221 | 2.378 | –5.559 | 6.894 |
| *Analyst* | Information environment | 14645 | 1.361 | 1.197 | 0.000 | 3.784 |

## 3. Empirical results

### 3.1. Parallel trend test

The parallel trend assumption must be met before use the DID method. In order to support this premise, the dummy variable *Current* is set to 1 in the initial year of the *post* taking 1, which is assumed to be the starting year of the SSSC policy, and 0 otherwise. Dummy variables *Before4*, *Before3*, *Before2* and *Before1* are taken as 1 in first, second, third and fourth years before the policy start year respectively, and 0 otherwise. The dummy variables *After1*, *After2* and *After3* are taken as 1 in first, second and third years after the policy start year respectively, and 0 otherwise. The remaining control variables correspond with the baseline regression. Table 2 reports the estimation results of the parallel trend test. The coefficients values of *Before4*, *Before3*, *Before2* and *Before1* are close to 0 and insignificant, which are consistent with the parallel trend hypothesis. In columns (1) and (2), the coefficient of *Current* is significant, indicating that the total level and quality of enterprise green innovation was significantly affected in the year of implementation of the SSSC policy. In column (3), the coefficient of *Current* is not significant, indicating that there is a lag in the impact of the SSSC policy on the quantity of enterprise green innovation. The coefficients of *After1*, *After2* and *After3* are all significant, demonstrating the sustainability of the SSSC policy's effect on enterprise green innovation.

Table 2. Estimation results of the parallel trend test

| Variable | (1) | (2) | (3) |
|---|---|---|---|
| | *LnTotal* | *LnQual* | *LnQuan* |
| *Before4* | 0.066 | –0.017 | 0.070 |
| | (1.014) | (–0.316) | (1.311) |
| *Before3* | –0.032 | –0.048 | –0.021 |
| | (–0.716) | (–1.263) | (–0.577) |
| *Before2* | 0.025 | –0.022 | 0.053 |
| | (0.542) | (–0.565) | (1.393) |
| *Before1* | –0.013 | –0.018 | –0.012 |
| | (–0.294) | (–0.482) | (–0.329) |

*End of Table 2*

| Variable | (1) | (2) | (3) |
|---|---|---|---|
| | *LnTotal* | *LnQual* | *LnQuan* |
| *Current* | 0.099** | 0.079** | 0.059 |
| | (2.220) | (2.084) | (1.620) |
| *After1* | 0.132*** | 0.134*** | 0.088** |
| | (2.944) | (3.541) | (2.411) |
| *After2* | 0.177*** | 0.189*** | 0.105*** |
| | (4.140) | (5.218) | (2.984) |
| *After3* | 0.269*** | 0.227*** | 0.196*** |
| | (6.270) | (6.236) | (5.579) |
| *Size* | 0.403*** | 0.338*** | 0.279*** |
| | (35.208) | (34.899) | (29.823) |
| *ListAge* | –0.080*** | –0.066*** | –0.050*** |
| | (–5.443) | (–5.346) | (–4.184) |
| *Lev* | 0.082 | 0.014 | 0.144*** |
| | (1.201) | (0.251) | (2.595) |
| *ROA* | –0.166 | –0.251* | –0.125 |
| | (–0.978) | (–1.745) | (–0.895) |
| *Cashflow* | –0.454*** | –0.433*** | –0.296** |
| | (–2.733) | (–3.082) | (–2.176) |
| *Indep* | 0.153 | 0.183 | 0.159 |
| | (0.996) | (1.410) | (1.267) |
| *Dual* | –0.039** | –0.023 | –0.029* |
| | (–2.015) | (–1.419) | (–1.818) |
| *TobinQ* | 0.045*** | 0.057*** | 0.022*** |
| | (5.620) | (8.420) | (3.372) |
| *SOE* | 0.099*** | 0.124*** | 0.000 |
| | (4.905) | (7.230) | (0.019) |
| *Top1* | –0.449*** | –0.444*** | –0.208*** |
| | (–7.479) | (–8.732) | (–4.237) |
| *KZ* | 0.001 | –0.005 | 0.002 |
| | (0.133) | (–0.775) | (0.397) |
| *Analyst* | 0.094*** | 0.079*** | 0.053*** |
| | (10.040) | (9.879) | (6.919) |
| *Constant* | –8.057*** | –6.920*** | –5.659*** |
| | (–33.875) | (–34.349) | (–29.073) |
| *Industry* | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes |
| N | 14,645 | 14,645 | 14,645 |
| $R^2$ | 0.368 | 0.331 | 0.327 |

*Note*: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively, and the values in parentheses are t-values, as in the following table.

### 3.2. Propensity score matching

Since the underlying enterprises of SSSC are not randomly selected, the samples of the experimental and control groups may differ significantly with respect to green innovation. Therefore, this study uses the propensity score matching method (PSM) to screen the samples, identify matched control groups for the experimental groups, and rerun regression analysis on the paired samples to address the endogeneity issue brought by sample self-selection. Specifically, in the full sample, firm size (*Size*), years of listing (*ListAge*), return on assets (*ROA*), cashflow ratio (*Cashflow*), whether state-owned enterprise(*SOE*), gearing ratio(*Lev*), percentage of top shareholder ownership (*Top1*), percentage of independent directors (*Indep*), Tobin's Q value (*TobinQ*), whether dual position (*Dual*), financing constraints (*KZ*) and information environment (*Analyst*) are used as covariates, and the propensity scores of sample enterprises are calculated using Logit model regression, and new experimental and control group samples are drawn using nearest neighbor matching 1:1 no put-back. Finally, 4915 matched samples are obtained. Before the re-estimation, the matched sample was tested for validity and the results are shown in Table 3. The experimental and control groups of the matched samples are no longer significantly different in terms of covariates.

Table 3. The PSM validity test

| Variable | Unmatched/ Matched | Experimental group mean | Control group mean | Difference | t-value | p-value |
|---|---|---|---|---|---|---|
| *Size* | Unmatched | 22.995 | 21.455 | 146.5 | 88.940 | 0.000 |
| | Matched | 22.068 | 22.100 | –3.100 | –1.290 | 0.196 |
| *ListAge* | Unmatched | 2.479 | 2.093 | 53.600 | 32.270 | 0.000 |
| | Matched | 2.320 | 2.320 | 0.000 | 0.010 | 6950.994 |
| *Lev* | Unmatched | 0.462 | 0.415 | 22.800 | 13.760 | 0.000 |
| | Matched | 0.437 | 0.440 | –1.300 | –0.470 | 0.638 |
| *ROA* | Unmatched | 0.525 | 0.021 | 53.000 | 31.990 | 0.000 |
| | Matched | 0.341 | 0.035 | –1.500 | –0.060 | 0.547 |
| *Cashflow* | Unmatched | 0.568 | 0.034 | 34.400 | 20.80 | 0.000 |
| | Matched | 0.418 | 0.043 | –1.200 | –0.440 | 0.658 |
| *Indep* | Unmatched | 0.372 | 0.376 | –9.100 | –5.500 | 0.000 |
| | Matched | 0.371 | 0.370 | 1.100 | 0.390 | 0.695 |
| *Dual* | Unmatched | 0.202 | 0.302 | –23.100 | –13.94 | 0.000 |
| | Matched | 0.220 | 0.229 | –2.100 | –0.750 | 0.452 |
| *TobinQ* | Unmatched | 1.921 | 2.164 | –17.500 | –10.560 | 0.000 |
| | Matched | 1.926 | 1.907 | 1.400 | 0.540 | 0.590 |
| *SOE* | Unmatched | 0.483 | 0.312 | 35.400 | 21.450 | 0.000 |
| | Matched | 0.423 | 0.419 | 0.800 | 0.290 | 0.773 |
| *Top1* | Unmatched | 0.363 | 0.316 | 32.5000 | 19.710 | 0.000 |
| | Matched | 0.327 | 0.329 | –1.000 | –0.350 | 0.727 |
| *KZ* | Unmatched | 0.990 | 1.436 | –18.800 | –11.380 | 0.000 |
| | Matched | 1.301 | 1.297 | 0.200 | 0.060 | 0.952 |
| *Analyst* | Unmatched | 1.988 | 0.778 | 116.600 | 70.820 | 0.000 |
| | Matched | 1.190 | 1.269 | –7.600 | –2.700 | 0.007 |

### 3.3. Baseline regression analysis

First, the multicollinearity of the variables in the model is tested, and the results are shown in Table 4. Among them, the values of the variance inflation factor (VIF) are all less than 4, indicating that the model does not have serious multicollinearity problems. Then, a two-way fixed-effects model is used to estimate the impact of the SSSC policy on enterprise green innovation and multiple cointegration is tested for each variable in the model. The results of the baseline regression are shown in Table 5. How the SSSC policy affected the overall level, quality, and quantity of enterprise green innovation is reported in Table 5's columns (1), (2), and (3), respectively. It can be seen that the coefficients of SSSC policy are significantly positive, which indicates that the SSSC policy not only significantly raises the total level of enterprise green innovation, but also significantly raises the quantity and quality. Hypothesis 1 of this study is verified.

Specifically, compared to control group enterprises, the implementation of the SSSC policy has increased the total level of green innovation of treatment group enterprises by 17.6%, the quality of green innovation by 19.7%, and the quantity of green innovation by 6.9%. This also indicates that foreign investors are more interested in the ability and quality of green innovation than the quantity of green innovation, thus making the SSSC policy more effective in promoting the total level and quality of green innovation. This is consistent with the results of the existing literature (Sha et al., 2022; Moshirian et al., 2021). The contribution of foreign investors to the quality of firm innovation tends to be more significant relative to the quantity of innovation (Moshirian et al., 2021). In the long run, high-quality innovation can bring greater returns to enterprises and is more attractive to foreign investors. At the same time, enterprises invest more in high-quality innovation and take more risks, and the capital and advanced investment concepts brought by capital market opening provide better conditions for it (Luong et al., 2017).

Table 4. Results of VIF test

| *Variable* | *treat×post* | *Size* | *ListAge* | *Lev* | *ROA* | *Cashflow* | *Indep* |
|---|---|---|---|---|---|---|---|
| VIF | 1.18 | 2.38 | 1.87 | 3.53 | 1.46 | 1.72 | 1.03 |
| Variable | *Dual* | *TobinQ* | *SOE* | *Top1* | *KZ* | *Analyst* | |
| VIF | 1.13 | 1.54 | 1.47 | 1.13 | 3.52 | 1.37 | |

Table 5. Estimation results of the baseline regression

| Variable | (1) | (2) | (3) |
|---|---|---|---|
| | *LnTotal* | *LnQual* | *LnQuan* |
| *treat×post* | 0.176*** | 0.197*** | 0.069** |
| | (5.144) | (7.139) | (2.504) |
| *Size* | 0.331*** | 0.258*** | 0.229*** |
| | (13.728) | (13.205) | (11.757) |
| *ListAge* | –0.078*** | –0.063*** | –0.050** |
| | (–3.031) | (–2.984) | (–2.406) |

*End of Table 5*

| Variable | (1) | (2) | (3) |
|---|---|---|---|
| | *LnTotal* | *LnQual* | *LnQuan* |
| *Lev* | 0.224* | 0.158 | 0.206** |
| | (1.820) | (1.583) | (2.067) |
| *ROA* | 0.164 | 0.015 | 0.038 |
| | (0.536) | (0.062) | (0.152) |
| *Cashflow* | –0.266 | –0.253 | –0.201 |
| | (–0.960) | (–1.128) | (–0.897) |
| *Indep* | 0.401 | 0.492** | 0.158 |
| | (1.497) | (2.271) | (0.731) |
| *Dual* | –0.083** | –0.052* | –0.065** |
| | (–2.505) | (–1.925) | (–2.443) |
| *TobinQ* | 0.046*** | 0.055*** | 0.019 |
| | (2.953) | (4.367) | (1.526) |
| *SOE* | 0.121*** | 0.133*** | 0.007 |
| | (3.681) | (5.026) | (0.251) |
| *Top1* | –0.393*** | –0.370*** | –0.146* |
| | (–3.852) | (–4.477) | (–1.772) |
| *KZ* | 0.000 | –0.010 | 0.005 |
| | (0.013) | (–1.024) | (0.457) |
| *Analyst* | 0.075*** | 0.062*** | 0.043*** |
| | (4.825) | (4.963) | (3.453) |
| *Constant* | –6.731*** | –5.438*** | –4.632*** |
| | (–12.901) | (–12.870) | (–10.981) |
| *Industry* | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes |
| N | 4,915 | 4,915 | 4,915 |
| $R^2$ | 0.263 | 0.216 | 0.243 |

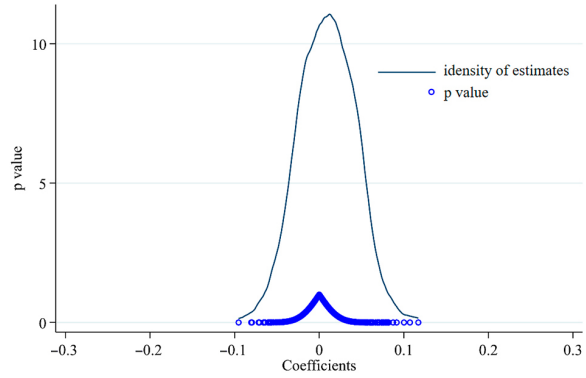
## 3.4. Robustness tests

### 3.4.1. Placebo test

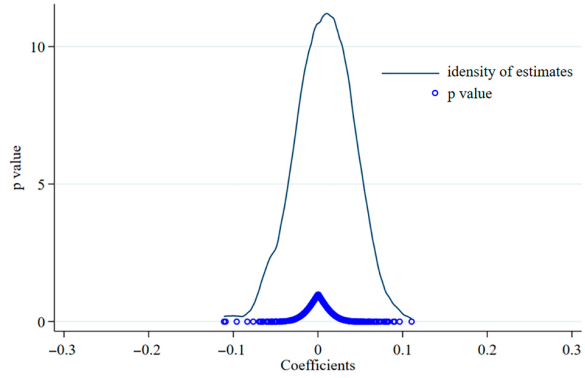
Considering that the baseline regression results may be disturbed by random factors, this study randomly selected 1000 samples from the total samples as the treatment group, and constructed a virtual randomized trial of the SSSC policy. According to the baseline regression model, the total level, quality and quantity of enterprise green innovation are tested respectively, and the regression coefficient and p-value are obtained again. To improve the validity of the placebo test, each procedure is repeated 500 times. The dummy regression coefficients and p-values of the SSSC policy are finally plotted as shown in Figure 1. As can be seen, the dummy estimated coefficients obtained from the three sets of stochastic simulated regression are concentrated around 0, which is more in line with the normal distribution and differs significantly from the true coefficients in the baseline regression results. The p-values

of the stochastic simulated regression are greater than 0.1, which is significantly different from the true p-value in the baseline regression results. This indicates that the previous baseline regression results are not due to other unobservable random factors outside the model, which confirms the robustness of the baseline regression results in this study.

a) Placebo test result of the total level of green innovation




b) Placebo test result of the quality of green innovation




c) Placebo test result of the quantity of green innovation

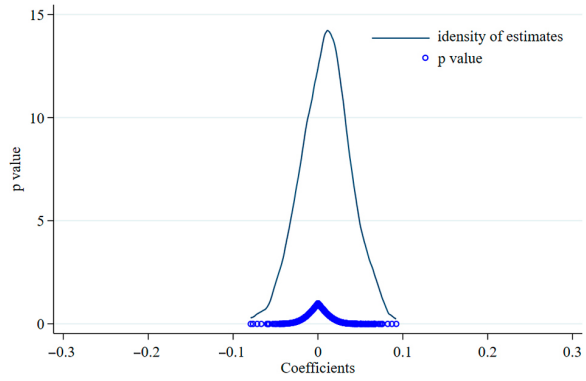



Figure 1. Placebo test result

### 3.4.2. Replacing the treatment group samples

On the one hand, A + H cross-listed enterprises are used as the replacement treatment group, and the sample is obtained by matching them with the original control group using the PSM method and re-estimated. The regression results are shown in columns (1)–(3) in Table 6. As we can see, the estimated coefficients of SSSC policy are not significant, indicating that the SSSC policy does not have a significant impact on green innovation of A+H cross-listed enterprises. These enterprises have already introduced foreign investors and are in a state of capital market opening. As a result, they are able to obtain IPO premiums and lower financing costs to ease their financing constraints, while the stricter legal constraints and market regulations make their information more transparent. This effect illustrates the robustness of the baseline regression results. On the other hand, the enterprises that newly entered SSSC from 2015 to 2019 and were not transferred out are used as the replacement treatment group, and the sample is obtained by matching them with the original control group using the PSM method and re-estimated. The regression results are shown in columns (4)–(6) in Table 6. As we can see, the estimated coefficient of SSSC policy is significantly positive, indicating that the enterprises subsequently transferred to SSSC are still significantly affected in terms of the total level, quality and quantity of green innovation. This again illustrates the robustness of the baseline regression results.

Table 6. Estimation results after replacing the treatment group samples

| Variable | A + H cross-listed enterprises as the replacement treatment group | | | Newly entered SSSC enterprises as the replacement treatment group, | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | *LnTotal* | *LnQual* | *LnQuan* | *LnTotal* | *LnQual* | *LnQuan* |
| *treat×post* | –0.071 | –0.074 | –0.051 | 0.143*** | 0.143*** | 0.049* |
| | (–0.568) | (–0.665) | (–0.503) | (3.966) | (4.942) | (1.680) |
| *Size* | 0.352*** | 0.302*** | 0.264*** | 0.223*** | 0.182*** | 0.151*** |
| | (5.790) | (5.627) | (5.364) | (11.103) | (11.272) | (9.296) |
| *ListAge* | –0.152* | –0.089 | –0.140** | –0.036* | –0.039** | –0.012 |
| | (–1.819) | (–1.198) | (–2.059) | (–1.657) | (–2.202) | (–0.682) |
| *Lev* | 0.296 | 0.143 | 0.256 | 0.198* | –0.013 | 0.301*** |
| | (0.649) | (0.354) | (0.693) | (1.901) | (–0.155) | (3.583) |
| *ROA* | 0.363 | –0.262 | 0.599 | 0.192 | 0.121 | 0.121 |
| | (0.310) | (–0.252) | (0.632) | (0.962) | (0.754) | (0.749) |
| *Cashflow* | –1.610 | –1.126 | –1.143 | –0.077 | 0.005 | –0.040 |
| | (–1.544) | (–1.220) | (–1.353) | (–0.335) | (0.030) | (–0.216) |
| *Indep* | 2.361** | 2.474*** | 1.371* | –0.203 | –0.021 | –0.127 |
| | (2.530) | (2.995) | (1.813) | (–0.811) | (–0.106) | (–0.632) |

*End of Table 6*

| Variable | A + H cross-listed enterprises as the replacement treatment group | | | Newly entered SSSC enterprises as the replacement treatment group, | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | *LnTotal* | *LnQual* | *LnQuan* | *LnTotal* | *LnQual* | *LnQuan* |
| *Dual* | 0.189 | 0.163 | 0.169 | 0.010 | 0.020 | –0.002 |
| | (1.191) | (1.161) | (1.313) | (0.334) | (0.832) | (–0.062) |
| *TobinQ* | –0.036 | –0.011 | –0.031 | 0.003 | 0.004 | 0.002 |
| | (–0.581) | (–0.199) | (–0.610) | (0.987) | (1.441) | (0.836) |
| *SOE* | 0.643*** | 0.439*** | 0.579*** | 0.063* | 0.089*** | –0.012 |
| | (4.948) | (3.819) | (5.495) | (1.773) | (3.142) | (–0.423) |
| *Top1* | –0.537 | –0.638* | –0.080 | –0.593*** | –0.587*** | –0.245*** |
| | (–1.285) | (–1.726) | (–0.236) | (–5.948) | (–7.350) | (–3.042) |
| *KZ* | –0.027 | –0.025 | –0.013 | 0.013 | 0.009 | 0.007 |
| | (–0.604) | (–0.620) | (–0.342) | (1.286) | (1.188) | (0.931) |
| *Analyst* | 0.124** | 0.116** | 0.059 | 0.051*** | 0.028** | 0.040*** |
| | (2.264) | (2.393) | (1.331) | (3.532) | (2.442) | (3.473) |
| *Constant* | –7.871*** | –7.065*** | –5.953*** | –4.006*** | –3.330*** | –2.846*** |
| | (–5.977) | (–6.061) | (–5.579) | (–9.582) | (–9.941) | (–8.439) |
| *Industry* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 408 | 408 | 408 | 5,138 | 5,138 | 5,138 |
| $R^2$ | 0.431 | 0.364 | 0.440 | 0.202 | 0.157 | 0.187 |

### 3.4.3. Excluding special samples

On the one hand, since the official launch of the Shanghai-Hong Kong stock connect and Shenzhen-Hong Kong stock connect policy took place in November 2014 and December 2016, in order to avoid the uncertainty of the year, the 2014 and 2016 samples are excluded and DID estimation is conducted again. The results are reported in columns (1)–(3) in Table 7. On the other hand, the Shanghai-London stock connect policy, which signifies a further capital market opening, is launched in 2019. Considering that the start of this policy is during the study period and may also affect enterprise green innovation, in order to avoid its interference with the regression results, the regression is re-run by excluding 2019 and later samples. The results are reported in columns (4)–(6) of Table 7. The estimated coefficients of the SSSC policy are significantly positive at the 1% level for both samples. The estimated coefficients of the SSSC policy on the total level of green innovation and the quality of green innovation are also much larger than the quantity of green innovation. This further demonstrates the validity of the baseline regression findings in this study.

Table 7. Estimation results after excluding special samples

| Variable | Excluding samples from the year SSSC was launched | | | Excluding the sample after the launch of Shanghai-London stock connect | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | *LnTotal* | *LnQual* | *LnQuan* | *LnTotal* | *LnQual* | *LnQuan* |
| *treat×post* | 0.185*** | 0.194*** | 0.083** | 0.173*** | 0.177*** | 0.082** |
| | (4.564) | (5.852) | (2.556) | (4.329) | (5.500) | (2.542) |
| *Size* | 0.314*** | 0.242*** | 0.218*** | 0.289*** | 0.219*** | 0.206*** |
| | (11.898) | (11.192) | (10.286) | (10.243) | (9.683) | (9.008) |
| *ListAge* | –0.103*** | –0.092*** | –0.059** | –0.076*** | –0.059** | –0.055** |
| | (–3.607) | (–3.968) | (–2.566) | (–2.586) | (–2.490) | (–2.287) |
| *Lev* | 0.336** | 0.192* | 0.305*** | 0.326** | 0.163 | 0.300*** |
| | (2.471) | (1.724) | (2.791) | (2.394) | (1.489) | (2.722) |
| *ROA* | –0.004 | –0.118 | –0.084 | 0.205 | 0.096 | 0.050 |
| | (–0.011) | (–0.438) | (–0.319) | (0.570) | (0.335) | (0.173) |
| *Cashflow* | –0.350 | –0.208 | –0.248 | –0.504* | –0.453* | –0.265 |
| | (–1.139) | (–0.827) | (–1.003) | (–1.711) | (–1.917) | (–1.111) |
| *Indep* | 0.360 | 0.364 | 0.116 | 0.450 | 0.348 | 0.282 |
| | (1.221) | (1.504) | (0.488) | (1.505) | (1.451) | (1.164) |
| *Dual* | –0.060 | –0.031 | –0.049* | –0.073* | –0.034 | –0.055* |
| | (–1.624) | (–1.004) | (–1.660) | (–1.943) | (–1.121) | (–1.836) |
| *TobinQ* | 0.033* | 0.037*** | 0.014 | 0.053*** | 0.053*** | 0.031** |
| | (1.895) | (2.625) | (1.037) | (2.975) | (3.715) | (2.130) |
| *SOE* | 0.134*** | 0.144*** | 0.021 | 0.124*** | 0.142*** | 0.015 |
| | (3.680) | (4.849) | (0.729) | (3.404) | (4.851) | (0.500) |
| *Top1* | –0.456*** | –0.392*** | –0.181** | –0.376*** | –0.345*** | –0.135 |
| | (–4.046) | (–4.242) | (–2.003) | (–3.329) | (–3.802) | (–1.480) |
| *KZ* | –0.011 | –0.012 | –0.006 | –0.015 | –0.015 | –0.004 |
| | (–0.875) | (–1.110) | (–0.539) | (–1.114) | (–1.475) | (–0.391) |
| *Analyst* | 0.047*** | 0.041*** | 0.018 | 0.063*** | 0.053*** | 0.038*** |
| | (2.727) | (2.935) | (1.272) | (3.677) | (3.841) | (2.721) |
| *Constant* | –6.233*** | –4.914*** | –4.337*** | –5.885*** | –4.553*** | –4.216*** |
| | (–10.941) | (–10.526) | (–9.483) | (–9.696) | (–9.348) | (–8.584) |
| *Industry* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3,951 | 3,951 | 3,951 | 3,873 | 3,873 | 3,873 |
| $R^2$ | 0.268 | 0.210 | 0.252 | 0.251 | 0.196 | 0.228 |

### 3.5. Channel tests

According to the regression results in the preceding section, the SSSC policy significantly promotes enterprise green innovation. In order to further investigate the transmission channels of the SSSC policy on the green innovation of enterprises, we refer to the study of Li et al. (2023) and use financing constraints and information environment as channel variables to conduct channel tests. The results are reported in Table 8. The results in column (1) show that the coefficient of the impact of the SSSC policy on *KZ* is negative at the 1% level, indicating that the launch of the policy helps to alleviate the level of financing constraints of enterprises. At the same time, financing constraints can lead to a lack of R&D funds for firms, which is an important inhibiting factor for green innovation in enterprises, and this inhibiting effect is more severe compared to general innovation activities (Yu et al., 2021). Therefore, the financing constraint is one of the channels, and the launch of the SSSC policy can effectively alleviate the financing constraint of enterprises and thus promote their green innovation. The results in column (2) show that the coefficient of the impact of the policy on the number of *Analyst* is positive at the 1% level, indicating that the launch of the policy helps to improve the information environment of enterprises. The more transparent the enterprise information environment is, and the lower the information asymmetry between firms and investors, the more pressure investors' concerns about environmental issues will put on enterprises to innovate green (Fiorillo et al., 2022). Therefore, the information environment is one of the channels, and the launch of the policy can effectively improve the information environment of enterprises and thus promote their green innovation. Hypothesis 2 and 3 of this study are verified.

Table 8. Estimation results of the channel test

| Variable | Financing constraints | Information environment |
|---|---|---|
| | (1) | (2) |
| | KZ | Analyst |
| *treat×post* | –0.157*** | 0.287*** |
| | (–3.971) | (8.751) |
| *Size* | 6.686*** | 0.547*** |
| | (63.106) | (24.570) |
| *ListAge* | –7.056*** | –0.408*** |
| | (–20.736) | (–17.815) |
| *Lev* | –14.338*** | –0.211* |
| | (–58.036) | (–1.869) |
| *ROA* | 0.591* | 4.425*** |
| | (1.904) | (15.464) |
| *Cashflow* | –0.074* | 0.067 |
| | (–1.939) | (0.254) |
| *Indep* | 0.514*** | 0.339 |
| | (31.558) | (1.366) |

*End of Table 8*

| Variable | Financing constraints | Information environment |
|---|---|---|
| | (1) | (2) |
| | KZ | Analyst |
| *Dual* | 0.003 | 0.098*** |
| | (0.075) | (3.170) |
| *TobinQ* | –0.316*** | 0.161*** |
| | (–2.671) | (11.533) |
| *SOE* | –0.157*** | –0.095*** |
| | (–3.971) | (–3.058) |
| *Top1* | –0.164*** | –0.504*** |
| | (–5.874) | (–5.202) |
| *KZ* | | –0.055*** |
| | | (–4.744) |
| *Analyst* | –0.113*** | |
| | (–6.322) | |
| *Constant* | 1.139* | –10.219*** |
| | (1.881) | (–21.024) |
| *Industry* | Yes | Yes |
| *Year* | Yes | Yes |
| N | 4,915 | 4,915 |
| $R^2$ | 0.789 | 0.343 |

## 4. Heterogeneity analysis

### 4.1. Heterogeneity of property rights

According to the nature of property rights of the sample enterprises, the sample is separated into two groups of "Non-SOEs" and "SOEs", and the estimation results are shown in Table 9. It shows that for non-SOEs, the SSSC policy has a significant impact on the total level, quantity and quality of green innovation. For SOEs, the SSSC policy only has a significant impact on the quality of green innovation, and the impact coefficient is smaller than that of non-SOEs. This indicates that the SSSC policy has a stronger impact on the total level, quantity and quality of green innovation of non-SOEs, and only the quality of green innovation of SOEs is affected. On the one hand, compared with non-SOEs, SOEs are able to receive more resource support and policy tilt from the government, have better governance mechanisms, and face weaker financing constraints. At the same time, due to the special attributes, SOEs are expected to take on more social responsibility, and this social responsibility is a mandatory, statutory corporate goal. As a result, SOEs are more focused on enterprise green development, their own green innovation capacity is higher, and they are less influenced by foreign investors (Yuan & Cao, 2022; Cull et al., 2015). On the other hand, non-SOEs face more intense market competition and need to use the funds to rapidly and comprehensively

improve green innovation to gain investors' favor. SOEs take on more social responsibility and are more in need of tackling important technology areas. Therefore, after obtaining funding, they focus more on improving the quality of green innovation (Fang et al., 2021; Xu et al., 2015).

Table 9. Estimation results of the heterogeneity of property rights

| Variable | *LnTotal* | | *LnQual* | | *LnQuan* | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Non-SOEs | SOEs | Non-SOEs | SOEs | Non-SOEs | SOEs |
| *treat×post* | 0.290*** | 0.050 | 0.269*** | 0.083** | 0.149*** | 0.002 |
| | (5.904) | (1.007) | (6.828) | (2.004) | (3.762) | (0.059) |
| *Size* | 0.221*** | 0.388*** | 0.167*** | 0.298*** | 0.150*** | 0.277*** |
| | (6.441) | (10.716) | (6.064) | (9.836) | (5.438) | (9.537) |
| *ListAge* | –0.064* | –0.122*** | –0.069** | –0.096** | –0.017 | –0.093*** |
| | (–1.926) | (–2.730) | (–2.560) | (–2.558) | (–0.615) | (–2.596) |
| *Lev* | 0.519*** | 0.191 | 0.360*** | 0.138 | 0.374*** | 0.220 |
| | (3.214) | (0.977) | (2.778) | (0.839) | (2.882) | (1.398) |
| *ROA* | 0.207 | 0.160 | –0.098 | 0.285 | 0.135 | 0.005 |
| | (0.553) | (0.300) | (–0.328) | (0.639) | (0.450) | (0.011) |
| *Cashflow* | –0.373 | –0.517 | –0.279 | –0.490 | –0.274 | –0.260 |
| | (–1.034) | (–1.204) | (–0.964) | (–1.362) | (–0.943) | (–0.753) |
| *Indep* | –0.278 | 1.409*** | –0.331 | 1.496*** | –0.250 | 0.851** |
| | (–0.795) | (3.403) | (–1.182) | (4.311) | (–0.889) | (2.554) |
| *Dual* | –0.030 | –0.142** | –0.002 | –0.130** | –0.028 | –0.107* |
| | (–0.779) | (–2.061) | (–0.057) | (–2.249) | (–0.885) | (–1.930) |
| *TobinQ* | 0.004 | 0.116*** | 0.016 | 0.112*** | –0.003 | 0.064*** |
| | (0.237) | (3.896) | (1.039) | (4.488) | (–0.210) | (2.679) |
| *Top1* | –0.365** | –0.448*** | –0.349*** | –0.367*** | –0.106 | –0.209* |
| | (–2.546) | (–3.029) | (–3.032) | (–2.964) | (–0.917) | (–1.761) |
| *KZ* | –0.009 | –0.013 | –0.016 | –0.018 | 0.003 | –0.006 |
| | (–0.614) | (–0.605) | (–1.368) | (–0.950) | (0.256) | (–0.348) |
| *Analyst* | 0.099*** | 0.015 | 0.074*** | 0.029 | 0.065*** | –0.015 |
| | (4.994) | (0.616) | (4.652) | (1.396) | (4.082) | (–0.763) |
| *Constant* | –4.128*** | –8.185*** | –3.119*** | –6.559*** | –2.872*** | –5.863*** |
| | (–5.577) | (–10.106) | (–5.248) | (–9.665) | (–4.821) | (–9.005) |
| *Industry* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 2,833 | 2,090 | 2,833 | 2,090 | 2,833 | 2,090 |
| $R^2$ | 0.225 | 0.344 | 0.175 | 0.289 | 0.218 | 0.306 |

### 4.2. Heterogeneity of industry monopoly level

The Herfindahl.Hirschman Index (HHI) is used as a proxy variable for the degree of industry monopoly level (IM), and the sample is separated into two groups of "low IM" and "high IM" by using the mean value as the criterion. The estimation results are reported in Table 10. It can be seen that the SSSC policy has a positive effect on enterprise green innovation in both the low and high IM samples. However, the coefficients and significance of the impact of the policy on the total level, quality and quantity of green innovation in the low IM samples are larger than those in the high IM samples. This indicates that the policy of SSSC has a stronger effect on the total level, quality and quantity of green innovation of low IM enterprises. In less monopolistic industries, it is more difficult for enterprises to achieve competitive advantage and make excess profits, and they are more vulnerable to the problem of financing constraints (Spence, 1986; Bernini & Montagnoli, 2017). The SSSC policy can not only bring in a large amount of foreign capital to alleviate the financing constraints of enterprises, but also help enterprises improve their operation by introducing foreign institutional investors (McCahery et al., 2016). Therefore, executives of low IM have stronger incentives to engage in green innovation to obtain financial support and improve profitability.

Table 10. Estimation results of the heterogeneity of industry monopoly level

| Variable | *LnTotal* | | *LnQual* | | *LnQuan* | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Low IM | High IM | Low IM | High IM | Low IM | High IM |
| *treat×post* | 0.205*** | 0.114* | 0.219*** | 0.127** | 0.075** | 0.062 |
| | (4.806) | (1.830) | (6.204) | (2.564) | (2.206) | (1.223) |
| *Size* | 0.290*** | 0.377*** | 0.224*** | 0.280*** | 0.195*** | 0.281*** |
| | (9.547) | (8.358) | (8.891) | (7.823) | (8.037) | (7.643) |
| *ListAge* | –0.055* | –0.116** | –0.061** | –0.096*** | –0.017 | –0.078** |
| | (–1.675) | (–2.569) | (–2.258) | (–2.678) | (–0.661) | (–2.103) |
| *Lev* | 0.228 | 0.530** | 0.161 | 0.367** | 0.198 | 0.395** |
| | (1.446) | (2.446) | (1.231) | (2.134) | (1.569) | (2.237) |
| *ROA* | –0.642 | 0.596 | –0.563* | 0.328 | –0.661** | 0.579 |
| | (–1.618) | (1.094) | (–1.715) | (0.759) | (–2.087) | (1.303) |
| *Cashflow* | –0.416 | –0.212 | –0.379 | –0.074 | –0.278 | –0.070 |
| | (–1.185) | (–0.439) | (–1.305) | (–0.193) | (–0.992) | (–0.179) |
| *Indep* | 0.352 | 0.023 | 0.499* | –0.193 | 0.167 | –0.040 |
| | (1.065) | (0.047) | (1.825) | (–0.495) | (0.634) | (–0.099) |
| *Dual* | –0.085** | 0.035 | –0.045 | 0.021 | –0.067** | 0.030 |
| | (–2.041) | (0.587) | (–1.322) | (0.450) | (–2.010) | (0.610) |
| *TobinQ* | 0.037* | 0.030 | 0.043*** | 0.030 | 0.014 | 0.019 |
| | (1.827) | (1.080) | (2.594) | (1.322) | (0.857) | (0.817) |

*End of Table 10*

| Variable | *LnTotal* | | *LnQual* | | *LnQuan* | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Low IM | High IM | Low IM | High IM | Low IM | High IM |
| *SOE* | 0.140*** | 0.080 | 0.165*** | 0.065 | 0.025 | –0.001 |
| | (3.417) | (1.313) | (4.855) | (1.348) | (0.762) | (–0.017) |
| *Top1* | –0.368*** | –0.227 | –0.376*** | –0.109 | –0.089 | –0.153 |
| | (–2.903) | (–1.204) | (–3.588) | (–0.732) | (–0.877) | (–0.998) |
| *KZ* | –0.015 | –0.002 | –0.020 | –0.006 | –0.004 | 0.002 |
| | (–1.017) | (–0.113) | (–1.619) | (–0.363) | (–0.299) | (0.142) |
| *Analyst* | 0.085*** | 0.021 | 0.063*** | 0.035 | 0.059*** | –0.012 |
| | (4.258) | (0.782) | (3.818) | (1.642) | (3.707) | (–0.567) |
| *Constant* | –5.808*** | –7.611*** | –4.620*** | –5.712*** | –3.947*** | –5.663*** |
| | (–8.933) | (–7.690) | (–8.581) | (–7.268) | (–7.604) | (–7.017) |
| *Industry* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3,204 | 1,495 | 3,204 | 1,495 | 3,204 | 1,495 |
| $R^2$ | 0.291 | 0.253 | 0.243 | 0.187 | 0.267 | 0.251 |

### 4.3. Heterogeneity of regional marketization level

Referring to the Report on China's Marketization Index by Provinces (2021) compiled by Wang et al. (2021), the total marketization index is used to measure the regional marketization level (RM) of the province where the enterprise is located, and the sample is divided into "low RM" and "high RM" using the mean value as the criterion. The estimated results are reported in Table 11. It can be seen that the coefficients and significance of the impact of the policy on the total level, quality and quantity of green innovation in the high RM group are larger than those in the low RM group. This indicates that in regions with higher marketization levels, the SSSC policy has a stronger effect on the total level, quality and quantity of green innovation. The financial sector is more developed and capital competition is more intense in regions with higher RM, where enterprises are less prone to government intervention (Huang & Lei, 2021), enterprises are more in need of foreign capital introduced by capital market opening. The legal systems in high marketization regions are also better, investors' rights are completely protected, and enterprise environmental information disclosure is more appropriate (Cheng et al., 2017), which can reduce the information asymmetry between investors and enterprises (Du, 2018). This is conducive to enhancing the promotion by the SSSC policy.

Table 11. Estimation results of the heterogeneity of regional marketization level

| Variable | *LnTotal* | | *LnQual* | | *LnQuan* | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Low RM | High RM | Low RM | High RM | Low RM | High RM |
| *treat×post* | 0.009 | 0.281*** | 0.037 | 0.281*** | –0.030 | 0.140*** |
| | (0.174) | (6.127) | (0.882) | (7.419) | (–0.702) | (3.845) |
| *Size* | 0.373*** | 0.259*** | 0.272*** | 0.211*** | 0.290*** | 0.159*** |
| | (9.624) | (8.181) | (8.741) | (8.062) | (9.101) | (6.318) |
| *ListAge* | –0.106** | –0.077** | –0.093*** | –0.072*** | –0.071** | –0.035 |
| | (–2.519) | (–2.321) | (–2.739) | (–2.606) | (–2.042) | (–1.319) |
| *Lev* | –0.084 | 0.719*** | –0.082 | 0.524*** | –0.010 | 0.529*** |
| | (–0.438) | (4.527) | (–0.529) | (3.998) | (–0.065) | (4.200) |
| *ROA* | 0.316 | –0.055 | 0.106 | –0.136 | 0.029 | –0.044 |
| | (0.637) | (–0.145) | (0.265) | (–0.434) | (0.071) | (–0.144) |
| *Cashflow* | –0.665 | –0.289 | –0.513 | –0.256 | –0.581 | –0.087 |
| | (–1.509) | (–0.837) | (–1.445) | (–0.899) | (–1.601) | (–0.317) |
| *Indep* | 0.046 | 0.820** | 0.113 | 0.762*** | –0.054 | 0.467* |
| | (0.109) | (2.372) | (0.330) | (2.672) | (–0.155) | (1.703) |
| *Dual* | –0.006 | –0.107*** | 0.019 | –0.081** | 0.001 | –0.078** |
| | (–0.096) | (–2.650) | (0.393) | (–2.427) | (0.031) | (–2.430) |
| *TobinQ* | 0.053** | 0.036* | 0.055*** | 0.044*** | 0.047** | 0.006 |
| | (2.036) | (1.883) | (2.617) | (2.767) | (2.183) | (0.384) |
| *SOE* | 0.066 | 0.221*** | 0.093** | 0.217*** | –0.015 | 0.069* |
| | (1.339) | (4.960) | (2.365) | (5.913) | (–0.363) | (1.958) |
| *Top1* | –0.657*** | –0.239* | –0.585*** | –0.215* | –0.332** | –0.046 |
| | (–4.095) | (–1.788) | (–4.533) | (–1.953) | (–2.513) | (–0.433) |
| *KZ* | 0.004 | –0.017 | –0.006 | –0.020* | 0.005 | –0.003 |
| | (0.189) | (–1.164) | (–0.393) | (–1.653) | (0.315) | (–0.255) |
| *Analyst* | 0.057** | 0.075*** | 0.054*** | 0.057*** | 0.023 | 0.047*** |
| | (2.321) | (3.736) | (2.721) | (3.468) | (1.122) | (2.933) |
| *Constant* | –7.215*** | –5.525*** | –5.368*** | –4.631*** | –5.706*** | –3.391*** |
| | (–8.465) | (–8.144) | (–7.826) | (–8.270) | (–8.137) | (–6.297) |
| *Industry* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Year* | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 1,961 | 2,961 | 1,961 | 2,961 | 1,961 | 2,961 |
| $R^2$ | 0.250 | 0.299 | 0.179 | 0.256 | 0.238 | 0.271 |

## Conclusions and policy implications

The SSSC policy is an essential institutional innovation in Chinese capital market opening in recent years, and its economic significance has received widespread attention. It is significant to explore the impact and mechanism of the SSSC policy on enterprise green innovation for promoting high-quality economic development. Based on the data of Chinese A-share listed enterprises from 2010 to 2020, the impact of the SSSC policy on enterprise green innovation is tested quantitatively. The transmission channels are tested, and the heterogeneity is further explored.

It is found that the SSSC policy has significantly improved the total level, quality and quantity of enterprise green innovation, and the effect on the total level and quality is greater than the quantity. The SSSC policy can effectively alleviate the financing constraints faced by enterprises, improve the information environment of enterprises, and thus improve the total level, quality and quantity of their green innovation. There is heterogeneity in the nature of property rights, corporate social responsibility, industry monopoly and regional marketization in the promotion of enterprise green innovation by the SSSC policy. According to the above findings, the following policy recommendations are proposed to further promote the opening of the capital market and to facilitate the green innovation enhancement of enterprises.

First, further expand the level of capital market opening. The SSSC policy has opened up China's A-share market to foreign investors from Hong Kong, which has significantly raised the total level, quantity, and quality of green innovation. Therefore, within the scope of managed risk, the Chinese government should keep widening the opening of the capital market, improving the capital market system and exploring a policy system that is in line with China's development conditions. On the one hand, we should further expand the pilot scope and scale of the SSSC policy, relax the trading quota and other restrictions for investors, and motivate foreign investors to actively participate in the domestic capital market. On the other hand, we must take advantage of the SSSC's excellent experience, promote the implementation of Shanghai-London stock connect and Shanghai-Singapore stock connect policies, actively explore new modes of capital market opening, provide diversified investment channels for foreign investors, and strive to promote the integration of China's capital market and the international capital market, so as to stimulate the vitality of enterprise green innovation.

Second, further unblock the channels such as financing constraints and information environment, and expand the promotion role of capital market opening for enterprise green innovation. On the one hand, we should broaden the financing channels of green innovation enterprises, pay attention to cultivating high-quality investors who practice the concept of long-term value investment, and introduce more preferential policies for investing in green innovative enterprises to guide more investors to invest in green innovative enterprises, so as to alleviate their financing constraints to the greatest extent, and develop the positive role of capital market on green innovation of enterprises. On the other hand, we should pay attention to the cultivation of market information environment, strengthen the role of analysts as information intermediaries in information acquisition and transmission, encourage ana-

lysts and other information intermediaries to pay attention to the status of enterprise green innovation, fully explore and track enterprise information and issue professional analysis reports. At the same time, enterprises should be encouraged to establish a good relationship with analysts and actively disclose financial and non-financial information related to green innovation to reduce information asymmetry. So that the information on enterprise green innovation can be transmitted to external investors in a timely and accurate manner, and the capital flow can be guided to enterprises that actively carry out green innovation. In this way, the efficiency of capital allocation will be improved and the level of enterprise green innovation will be enhanced.

Third, adopt differentiated green innovation promotion initiatives. In the process of promoting green development, policy precision should be improved, differentiated policies should be formulated for the nature of different enterprises, and the role of capital market opening in promoting enterprise green innovation should be brought into play to a greater extent. On the one hand, increase the policy incentives for green innovation for state-owned enterprises and enterprises in high industry monopoly level, and induce them to seize the opportunity of capital market opening to improve their own green innovation level with the help of financing constraints and information environment channels. On the other hand, increase the open policy tilt to the lower marketization areas, through appropriate policy help to narrow the marketization differences between regions and alleviate the green development bottlenecks faced due to unbalanced regional development.

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