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Does Urban Greening Construction Promote Technological Innovation of Enterprises? Evidence from China*

Yongxiang Jiao, Fen Xu, Hongen Yang

School of Economics, Beijing Technology and Business University, Beijing, China,
email: xufen@btbu.edu.cn

Abstract

Based on data for cities and enterprises in China from 2009 to 2020, we examine the effect of urban greening construction on corporate technological innovation. Urban greening construction has a pronounced promoting effect on the technological innovation of enterprises, which is more significant among enterprises in the Eastern Region, enterprises in heavily polluting industries and state-owned enterprises. However, urban greening construction only has a significant promoting effect on enterprise invention and green patent applications and has no significant promoting effect on utility models and design patent applications. In addition, urban greening construction mainly enhances enterprise technological innovation by strengthening enterprise environmental responsibility undertaking, enhancing urban human capital density, and improving urban air quality. Promoting the urban marketability process can significantly enhance the role of urban greening construction in enterprise technological innovation.

Keywords: urban greening construction, enterprise technological innovation, green patent, air pollution, human capital, environmental responsibility, marketability

JEL Codes: D22, R50

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1. Introduction

Enterprise technological innovation has a strong spillover effect and is of great significance to the economic development of all countries. Therefore, based on practical needs, the academic research results on the driving factors of enterprise technological innovation are also quite rich. Among them, the discussion on the relationship between environmental protection and enterprise technological innovation has attracted much attention; its discussion mainly focuses on three aspects as follows.

The first is research into the relationship between investment in environmental governance and technological innovation of enterprises; the second is the discussion around the "Porter hypothesis" (Porter, 1995), where Ramanathan et al. (2017) proposed that environmental regulation can promote enterprise technological innovation by exerting external pressure and helping enterprises overcome organizational inertia. However, Albrizio et al. (2017) and Petroni et al. (2019) pointed out that environmental regulatory policies may inhibit technological innovation by raising factor prices, reducing foreign direct investment, and squeezing innovation resources. The third is analysis of the heterogeneity effect of different environmental regulation policies (Shen et al., 2019; Sun et al., 2021). Some scholars have explored the relationship between mandatory environmental regulations, such as environmental tax collection and environmental legislation, and enterprise innovation (Franco et al., 2017; Pang, 2022), while others have examined the relationship between market incentive environmental policies, such as environmental subsidies and environmental pollution liability insurance, and enterprise innovation (Wang et al., 2022; Lai et al., 2022). Moreover, some scholars have analysed the connection between voluntary environmental legislation, such as ISO 14001 environmental certification, and enterprise innovation (Lim et al., 2014; Jiang et al., 2020).

The above research results provide much empirical basis for us to correctly evaluate the relationship between environmental protection policies and enterprise technological innovation. However, we also find that there are still limitations in the following three aspects of the existing research. Firstly, existing studies focus on the relationship between enterprise environmental protection investment and enterprise technological innovation (Cai et al., 2016; Dubey et al., 2015; Oliva et al., 2019) while there is a lack of discussion on the impact of government environmental protection investment on enterprise technological innovation. Secondly, existing studies systematically analyse the effects of corporate social responsibility undertaking, regional air quality improvement and human capital supply increase on corporate technological innovation (Shi et al., 2023; Liu et al., 2023; Li et al., 2021); however, they have not delved into the motivation for increasing corporate social responsibility undertaking, as well as the sources of improving regional air quality and increasing human capital supply. Thirdly, existing studies have focused on the impact of heterogeneous environmental regulation policies on firms' technological innovation but have yet to fully consider the synergistic regulatory effects of critical features from regions, firms, and industries on the effects of environmental regulation policies.

Urban greening is the activity of planting plants in a city to improve the urban environment. Due to its ability to improve the quality of the urban environment and affect the city's reputation, urban greening construction is of great significance for regional environmental protection and economic development. First, urban greening construction is an essential public environmental investment activity led by local governments, which is an important embodiment of local government environmental protection performance. In general, the increase in local government environmental investment will have a significant impact on corporate environmental investment activities (Ma et al., 2022), and the environmental performance objectives set by the government inevitably influence the environmental performance objectives of enterprises, leading to changes in their environmental regulatory behaviours (Feng et al., 2022). Secondly, urban greening has a strong spillover effect, which can not only significantly improve the regional space environment, the quality of life of residents and ecosystem services (Cook, 2020) but also optimize the allocation of regional resources and drive the development of the entire city (Liotta et al., 2020). Therefore, it is inevitable to raise the question: can urban greening construction promote enterprise technological innovation by changing enterprise environmental behaviour, improving regional environmental quality and optimizing regional resource allocation?

Moreover, urban greening is a significant environmental protection policy, and different regions, industries and enterprises have apparent differences in compliance with government policies. Therefore, does this mean that the impact of urban greening construction on the technological innovation of enterprises has apparent heterogeneity? Finally, urban greening construction is a systematic project with a long business chain. It involves using and supervising government funds, benefits evaluation, etc., which is prone to corruption and other government failures. Then, can the promotion of the marketability process play a moderating role in the impact of urban greening construction on enterprise technological innovation?

As China's economy enters a stage of high-quality development, the country places more emphasis on ecological and environmental construction. The report of the 20th National Congress of the Chinese Communist Party in 2022 emphasizes the need to accelerate the green transformation of the development. It gives green development and innovative development greater prominence. Therefore, to clarify these above questions, this paper empirically explores the effect of urban greening on enterprise technological innovation and its mechanism using panel data from 2009 to 2020 for 291 cities and 4649 enterprises in China. The structure of this article is as follows. Section 2 is a literature review and hypothesis presentation. Section 3 describes the methodology and data. Section 4 offers the empirical results and an analysis. Section 5 verifies the mechanism, and the final part concludes.

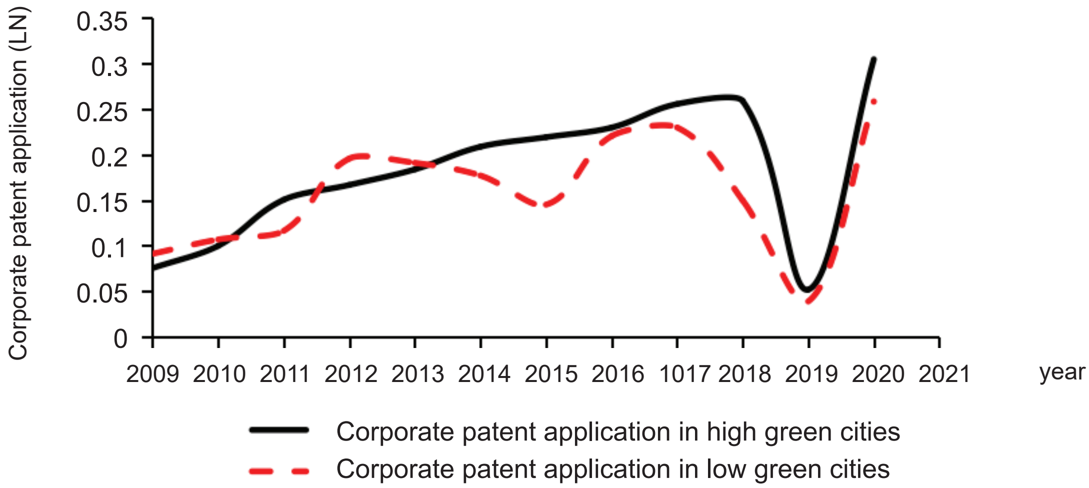
The main contributions of this paper are as follows: firstly, from the perspective of urban greening construction, we discuss the relationship between local government environmental investment and enterprise technological innovation and expand the research in related fields. Secondly, the heterogeneity effect of urban greening construction on corporate technological innovation is examined from the perspectives of regional economic development level, industrial pollution degree and enterprise ownership difference, and the influence of urban greening construction on the types of enterprise technological innovation is discussed from the perspective of patent heterogeneity. Thirdly, the intermediary mechanism of urban greening construction to promote enterprise technological innovation is analysed, it is proposed that urban greening construction can promote enterprise technological innovation by strengthening enterprise environmental responsibility, enhancing regional human capital, and improving air quality, and the positive moderating effect of marketability process on urban greening construction to promote enterprise technological innovation is verified. This study provides an empirical basis for accurate evaluation the external effects of urban greening construction, encouraging technological innovation of enterprises, and promoting the coordinated development of the economy and environment.

2. Literature Review and Hypothesis Presentation

2.1 Analysis of characteristics between urban greening and enterprise innovation

From the perspective of enterprise technological innovation, the critical performance of the enterprise technological innovation effect of urban greening construction is that the magnitude or average growth rate of corporate patent applications in cities with elevated greening is generally higher than in regions with lower greening. Therefore, we use matching data for cities and listed companies from 2009 to 2020 to conduct fact analysis based on two indicators: the magnitude of corporate patent applications and the green coverage rate of urban built-up areas, to preliminarily analyse whether urban greening construction can improve enterprise technological innovation. Specifically, areas with higher green coverage than the sample mean are defined as high-greening cities, and the remaining areas are lower-greening cities. Then, the relationship between urban greening construction and enterprise technological innovation is explained by trend comparison, and the results are shown in Figure 1.

Figure 1: Changes of corporate patent application under different greening levels



Source: authors' calculations

Figure 1 reflects the fluctuating trend of the number of corporate patent applications under diverse urban greening levels. Upon comparison, it is observed that the magnitude and growth rate of corporate patent applications in cities with elevated greening levels are considerably larger than those in regions with lower greening levels. Consequently, it is evident that as the urban greening construction level advances, the number of enterprise patent applications will also increase.

To further clarify whether a significant difference exists in the change of corporate patent applications under the grouping condition of urban greening level, a *t*-test was conducted based on this grouping variable. The results are presented in Table 1. The test results in Table 1 indicate that the mean value of corporate patent applications in regions with higher greening levels is significantly larger than in regions with lower greening levels at the significance level of 1%. Thus, the following hypothesis is posited:

Hypothesis 1: Urban greening construction will promote corporate technological innovation.

Table 1: t-test results

Indicators	High Green Level	Low Green level	t
Corporate patent applications	0.1880	0.1538	2.5687***

Notes: *** represents 1% significance level

Source: authors' calculations

2.2 Corporate environmental responsibility undertaking mechanism

Although urban greening construction cannot directly affect enterprises' production and operation behaviour, as an essential public environmental governance investment of local governments, urban greening construction has a significant "demonstration effect" on improving the environmental governance responsibility of enterprises (Jiao et al., 2023). First of all, investment in urban greening reflects the determination of local governments to participate in environmental governance. Under the government-led economic development model with Chinese characteristics, corporate policy compliance can effectively improve the communication and negotiation capability between enterprises and the government and obtain more support from external resources (Fan et al., 2019). Secondly, the increase in urban greening construction investments may increase the environmental attention of the government, the media and the public to the region, and this increase in urban environmental attention will force enterprises to assume environmental responsibilities actively. This is because, on the one hand, attention to the urban environment will stimulate the demand for green consumption and investment (Liao et al., 2018), and this market change will encourage enterprises to demonstrate their green image through environmental responsibility.

On the other hand, the increased attention to the urban environment will reduce the public's tolerance for negative environmental behaviour and make them pay more attention to the environmental protection information of enterprises in their jurisdiction. To avoid more social pressure and litigation risks, enterprises have to choose to undertake environmental responsibilities actively (Hart, 1996). Finally, green construction is an essential urban environmental infrastructure construction, and its construction adheres to the fundamental tenets of government leadership and social involvement. In this process, enterprises will actively assume environmental responsibilities to balance the conflict of stakeholders. However, corporate environmental responsibility can not only motivate enterprises to increase investment in innovation resources (Kim et al., 2014) but also enhance the technological innovation capability of small and medium-sized enterprises and polluting enterprises (Santos et al., 2021; Zhong et al., 2022) through resource linking among stakeholders. Considering the literature review above, urban greening construction can promote enterprise technological innovation by enhancing their environmental responsibility undertaking. Consequently, this paper suggests:

Hypothesis 2: Corporate environmental responsibility undertaking is an intermediary mechanism for urban greening construction to promote enterprise technological innovation.

2.3 Urban human capital promotion mechanism

As non-monetary welfare, urban greening construction will have a meaningful impact on regional resource allocation and economic development. Firstly, urban greening construction will promote the inflow of high-level labour elements and enhance urban human capital. This is because superior or skilled individuals have more options and weak job substitution. They have a more vital ability to bear economic pressure brought by changing working environments and prefer to work in areas with better environmental quality (Hunter et al., 2017). Secondly, urban greening construction will also increase regional industrial concentration. Firstly, improving the greening level will enhance the region's comparative advantage in geographical and environmental conditions and support enterprises in establishing their locations (Carlino et al., 2015). Secondly, the horizontal and vertical spillovers brought about by enterprise agglomeration will again strengthen the orientation of enterprise location. Finally, cities that pay attention to greening construction may have higher environmental performance standards and requirements, which will encourage the entry of knowledge- and technology-intensive high-tech industries and restrict the entry of polluting and low-productivity enterprises (Manderson et al., 2012). The agglomeration of high-tech industries will increase the city's human capital again by attracting more high-quality talents. In other words, the local government's investment in greening construction will form a virtuous circle via different paths to increase urban human capital and continuously enhance urban competitiveness. At the same time, according to the theories of urban economics and industrial agglomeration, both the labour supply advantages brought by the increase in urban human capital and the economies of scale brought by industrial agglomeration are conducive to improving the innovation capability of enterprises in the region. Specifically, the intra-industry spillover, inter-industry spillover and competition effect of urban human capital positively affect enterprise innovation (Lao et al., 2021).

Moreover, the improvement of industrial agglomeration itself will further strengthen industrial correlation, reduce production costs, obtain higher benefits and accelerate innovation (Kekezi et al., 2020). To sum up, urban greening construction can boost the enterprise's technological innovation by improving the regional human capital. Accordingly, this paper proposes:

Hypothesis 3: Regional human capital promotion is the intermediary mechanism for urban greening construction to promote enterprise technological innovation.

2.4 Urban air quality improvement mechanism

According to the existing literature, urban greening construction improves regional air quality by reducing the concentration of solid pollutants, alleviating the "heat island effect" and absorbing gaseous pollutants. High-density urban greening construction can purify the air in the region by decreasing the concentration of PM2.5, PM10 and other airborne particles and carbon dioxide (Wang et al., 2022). Urban green infrastructure, including vegetation, trees, grass and shrubs, can effectively cool and increase humidity, ventilate and induce wind and reduce the urban "heat island effect" (Hiemstra et al., 2017; Nastran et al., 2019). The vegetation barrier composed of continuous, dense, and tall vegetation can trap and reduce gaseous pollutants produced by vehicles through the absorption of gaseous pollutants by leaf pores, thus alleviating and eliminating air pollution (Nowak et al., 2018). Meanwhile, according to neoclassical economic growth theory (Grossman, 1972), the overlapping generation model (Blanchard, 1985) and the endogenous growth theory (Romer, 1986), environmental pollution has a very negative impact on labour force health and economic growth. Empirical studies by many scholars also support this conclusion that environmental pollution damages health and hinders economic growth (Azam et al., 2019).

On the contrary, improving environmental quality can alleviate labour health risks and promote economic growth, thus helping to promote enterprise investment and innovation (Jiang et al., 2020). Furthermore, the improvement of regional air quality can not only significantly reduce employee absenteeism, increase working hours, and improve work efficiency, but also reduce the costs of environmental regulation for enterprises, reduce compensations and ease the financing constraints of R&D enterprises, which provides productivity and capital advantages for enterprise technological innovation. Through the above analysis, improving greening levels can effectively improve urban air quality, conducive to enterprise technological innovation. Based on this, this paper proposes:

Hypothesis 4: Regional air quality improvement is an intermediary mechanism for urban greening construction to promote enterprise technological innovation.

2.5 Moderating effect of marketability process

In addition, urban greening construction may also face the problem of "government failure" in enhancing the technological innovation ability of enterprises. The investment amount of urban greening construction is usually extensive, whereby it is easy to breed and produce corruption and improper governance behaviours such as "government-enterprise collusion", "formalism" and "one-size-fits-all", resulting in low bid prices, poor construction quality and other problems of urban greening and financial waste. Even local governments manipulate, conceal or "strategically" modify environmental quality data to cope with false greening behaviours such as environmental performance assessment from the central government (Huihua et al., 2013; Ghanem et al., 2014), which will significantly reduce the external spillover effect of urban greening construction. However, promoting the regional marketability process will strengthen the public supervision mechanism, further regulate government behaviour and improve the efficiency of government resource allocation (Fan et al., 2019). In addition, regions with a higher level of marketability usually have a higher level of legal system and market competition, which not only helps exert the supervisory role of the market institutional environment in the corporate governance mechanism but also helps improve the utilization efficiency of corporate resources by improving the market incentive mechanism (Jiang et al., 2020). In other words, improving the marketability level can help reduce the limitations of urban greening construction in promoting the technological innovation of enterprises.

Moreover, in regions with higher marketability levels, the development of factor markets, product markets, intermediary organizations and legal system environments is usually more complete. Therefore, the promotion of the regional marketability process itself can also improve the technological innovation ability of enterprises from the following three aspects: the development of a factor market will promote the efficient and reasonable flow of high-level production factors such as workforce, capital and technology to the actual innovation activities, which is conducive to improving the product conversion rate of innovation achievements. A sound product market will improve product quality through market competition and increase the success rate of the enterprise product innovation market. Improving market intermediary organizations and the legal system environment will close the interaction and connection between innovation institutions and enhance advanced technologies' diffusion and spillover effect. Therefore, advancing the regional marketability process is likely conducive to enhancing the technological innovation effect of enterprises in urban greening construction. Therefore, this paper proposes:

Hypothesis 5: Promoting the marketability process will play a positive role in regulating urban greening to promote the technological innovation of enterprises.

3. Methodology and Data

3.1 Empirical models

To verify the basic conclusions of Hypothesis 1, the following benchmark regression model is established based on theoretical analysis:

$$Inov_{ijct} = \beta_0 + \beta_1 UGC_{ct} + \beta_2 R_{ct} + \beta_3 B_{ijct} + \lambda_i + \alpha_t + \varepsilon_{ijct} \tag{1}$$

Where *i, j, c, t* represent the enterprise, industry, city and year, respectively. $Inov_{ijct}$ represents enterprise technological innovation, which is mainly expressed by the number of enterprise patent applications ($LNPA_{ijct}$); the data come from the China Stock Market & Accounting Research (CSMAR) database, which is an accurate research-based database in the field of economy and finance developed by Aishima (Shenzhen) Data Technology Co. Ltd.; UGC_{ct} is the green coverage rate of urban built-up areas, which reflects the greening construction level of the city, the data come from the Reset database (www.reset.com).

If coefficient β_1 is significantly greater than 0, it indicates that urban greening construction can significantly promote technological innovation of enterprises. R_{ct} and B_{ijct} is the control variable at the city and enterprise levels, respectively, λ_i, α_t represents the fixed effects of enterprises and the fixed effects of years, and ε_{ijct} is a random disturbance term. In addition, considering that the disturbance terms of individuals within the same industry may be correlated, the robust standard error is clustered to the industry in the regression of the reference equation.

In order to verify the essential results of Hypotheses 2, 3 and 4, based on the mediation effect analysis approach established by Baron et al. (1986), this paper designs the following mediation utility test model:

$$MED_{ijct} = \gamma_0 + \gamma_1 UGC_{ct} + \gamma_2 R_{ct} + \gamma_3 B_{ijct} + \lambda_i + \alpha_t + \varepsilon_{ijct} \tag{2}$$

$$Inov_{ijct} = \delta_0 + \delta_1 UGC_{ct} + \delta_2 MED_{ijct} + \delta_3 R_{ct} + \delta_4 B_{ijct} + \lambda_i + \alpha_t + \varepsilon_{ijct} \tag{3}$$

Where MED_{ijct} is an intermediate variable. As an important environmental protection behaviour led by local governments, urban greening construction will have not only an impact on corporate environmental responsibility, but also an important impact on environmental quality and resource concentration in the region. Therefore, based on the theoretical analysis above, corporate environmental responsibility EER_{ijct}, urban human capital UHD_{ijct} and urban air quality UAQ_{ijct} represent the intermediary variables. Among them, EER_{ijct} represents the corporate environmental responsibility score; the rating data come from Sino-Securities Index Information Service (Shanghai) Co. Ltd., which covers all Chinese A-share listed companies. UHD_{ijct} is expressed by the ratio of college graduates to the city's total population. UAQ_{ijct} takes the ratio of the annual average concentration of PM2.5 to the total urban population as the proxy variable. The PM2.5 data are calculated based on the global average annual PM2.5 concentration data provided by the Center for Socio-economic Data and Applications at Columbia University; the data for the total population in the city comes from the Reset database (www.reset.com).

To verify the basic conclusions of Hypothesis 5, we set the following regulatory effect test model according to the regulatory effect test method:

$$Inov_{ijct} = \rho_0 + \rho_1 UGC_{ct} * MCP_{ct}\, \rho_2\, UGC_{ct} + \rho_3 MCP_{ct} + \rho_4 R_{ct} + \rho_5 B_{ijct} + \lambda_i + \alpha_t + \varepsilon_{ijct} \tag{4}$$

Among them, Equation (4) is the adjustment effect test equation, MCP_{ct} is represented by the urban marketability index; referring to the practice of Sun et al. (2021), we take 2009 as the base period and calculate the marketability index of different cities from six aspects: the development status of non-state-owned economy, the product market development, the factor market development, the degree of market service perfection, the degree of intellectual property protection, and the relationship between government and market, to reflect the marketability level of cities. $UGC_{ct} * MCP_{ct}$ is the interactive item; if the coefficients β_1 and ρ_1 are significantly greater than 0, it indicates that the promotion of the marketability process can enhance the promotion effect of urban greening on enterprise technology innovation.

3.2 Description of main variables

3.2.1 Explained variables

(1) Number of patent applications $LNPA_{ijct}$. They are expressed as the logarithm of the number of patent applications filed by the company plus 1. (2) Active enterprise technology innovation DPA_{ijct}. If a company files a patent application, it gets the value 1. Otherwise, we mark it as 0. (3) In order to reflect the difference in the impact of urban greening on the technological innovation ability of enterprises, the patent applications of enterprises are further divided into three categories: green patent applications, invention patent applications and utility model applications. The logarithm of different patent applications plus 1 is recorded as $LNGPA_{ijct}$, $LNFM_{ijct}$ and $LNXW_{ijct}$. DPA_{ijct} and $LNGPA_{ijct}$, $LNFM_{ijct}$ and $LNXW_{ijct}$ are mainly used for robustness tests and heterogeneity analysis.

3.2.2 Instrumental variables

We consider that endogenous issues such as missing variables and common interference factors may exist between urban greening construction and enterprise technical innovation. In order to strengthen the reliability of the benchmark regression, we chose the road and bridge area ratio (RBR_{ct}) and annual average precipitation (YRQ_{ct}) as the instrumental variables of urban greening construction for further regression testing. Among them, the area ratio of roads and bridges (RBR_{ct}) is expressed by the ratio of roads and bridges in the city to the urban administrative area, and the data comes from the Reset database (www.reset.com). The annual average precipitation (YRQ_{ct}) is calculated by weighting the daily precipitation of the city. To further reflect the impact of the actual annual precipitation of each city, it is expressed by the ratio of the annual average precipitation to the urban administrative area. The data are mainly from the geographical remote sensing ecological network (www.gisrs.cn). The main reasons for adopting RBR_{ct} and YRQ_{ct} as instrumental variables of urban greening construction are as follows: (1) Under certain conditions of urban administrative area, cities with extensive areas of roads and bridges may occupy the green coverage area to a certain extent, so the correlation requirements of instrumental variables can be met. Moreover, no studies have proved a direct correlation between the area of roads and bridges and the technological innovation of enterprises; this index also satisfies the exogenous hypothesis of instrumental variables. (2) Relatively abundant precipitation aids in cultivating and maintaining plants in urban green coverage areas, indicating that this index meets the requirement of correlation of instrumental variables. In addition, the annual average precipitation of the city is a natural phenomenon, which is unlikely to affect the technological innovation of enterprises directly, so this index also satisfies the exogenous hypothesis. In order to prevent the lack of credibility of using only RBR_{ct} and YRQ_{ct} as instrumental variables, we will also use the lag index widely used as an instrumental variable in similar studies to deal with endogenous problems jointly.

3.2.3 Control variables

In addition to the core explanatory variables mentioned above, we select a series of relevant characteristic variables as control variables from the urban and enterprise levels. (1) $RGDP_{ct}$, the urban GDP growth rate, reflects the regional economic development level. (2) FRG_{ct}, the urban RMB loan balance growth rate reflects the urban financial supply level. (3) LNA_{ijct}, the enterprise scale, is expressed by the logarithm of the enterprise's total assets plus 1. (4) ROE_{ijct}, return on equity, is used to control the company's profitability. (5) $LNSG_{ijct}$, for the scale of environmental protection investment of enterprises, the amount of environmental protection investment of enterprises is obtained by summing up the expenditures related to environmental protection under the items of construction in progress and administrative expenses in the notes to the annual report of listed companies, and then the logarithm is obtained by adding 1 to it. (6) $LNOSI_{ijct}$, the outward internationalization level of the enterprise, is expressed by the logarithm of the enterprise's overseas income plus 1. (7) GAP_{ijct}, the proportion of fixed assets, is expressed as the ratio of fixed assets to total assets. The data for all these variables were obtained from the Wind China financial database (www.wind.com.cn).

3.3 Sample description and data descriptive statistical analysis

We take the city-level and A-share listed company-level data from 2009 to 2020 as samples and process the data as follows: (1) Delete financial A-share listed companies such as banks, insurance, securities and futures with special financial statement rules. (2) Delete ST and *ST listed companies with extreme outliers. Therefore, we have obtained 55,789 pieces of data from 4649 A-share listed companies in the period 2009–2020.

Table 2: Descriptive statistical analysis results of main variables

Variables	Definition	Observations	Mean	S.D.	Min	Median	Qua (75%)	Max
LNPA	Number of enterprise patent applications	55788	0.1901	0.5903	0.0000	0.0000	0.0000	6.8742
DPA	If a firm files patent applications, gets the value 1, otherwise 0	55788	0.1292	0.3354	0.0000	0.0000	0.0000	1.0000
LNGPA	Number of enterprise green patent applications	55788	0.1709	0.6537	0.0000	0.0000	0.0000	6.7346
LNFM	Number of enterprise invention applications	55788	0.1035	0.4689	0.0000	0.0000	0.0000	6.0162
LNXW	Number of enterprise utility model and design applications	55788	0.1060	0.5224	0.0000	0.0000	0.0000	6.2086
UGC	Green coverage rate of urban built-up areas	55068	41.8604	4.5262	1.6400	42.0000	44.7400	95.2500
MCP	Urban marketability process	55068	11.3121	2.5011	4.5007	10.9568	13.0201	19.6944
UGC * MCP	The interaction items of UGC and MCP	55068	474.061	117.2500	13.2660	465.8584	550.1708	1320.1600
EER	Corporate environmental responsibility score	55788	37.7578	36.2337	0.0000	66.9400	72.9900	92.9300
UHD	Urban human capital density	55068	3.1582	2.5756	0.0409	2.1732	4.3772	12.7643
UAQ	Urban air quality	55068	0.0669	0.0653	0.0085	0.0507	0.0837	1.6871
RGDP	Urban GDP growth rate	54600	0.1026	0.0635	−0.3744	0.0970	0.1311	0.6146
FRG	The growth rate of the balance of urban RMB loans	54600	0.1258	0.0919	−0.2680	0.1265	0.1651	1.8560
LNA	Size of enterprise assets	45502	21.4784	1.5853	11.3483	21.3769	22.4148	28.6364
ROE	Corporate yield value	44822	11.0995	49.2234	−157.69	10.8034	19.0752	410.0110
LNSG	Scale of enterprises' investment in environment protection	55788	2.6489	6.0679	0.0000	0.0000	0.0000	27.0636
LNOSI	The level of outward internationalization of enterprises	27618	10.8276	9.5236	0.0000	16.7177	19.3869	25.5799
GAP	Proportion of fixed assets of enterprises	45057	0.2140	0.1631	0.0007	0.1828	0.3064	0.9711
RBR	Area ratio of roads and bridges	54600	1.1933	1.5148	0.1312	0.6406	1.4009	6.1337
YRQ	The actual annual precipitation of a city	55068	0.0051	0.0053	0.0006	0.0041	0.0060	0.0825

Source: authors' calculations

Table 2 reports the descriptive statistical results of the main variables in the urban greening construction and enterprise technological innovation sample. It can be seen from the table that during the observation period, the min and max values of enterprise technological innovation (LNPA) are 0 and 6.8742, respectively, the mean is 0.1901, and the median is 0, indicating that there are apparent differences in technological innovation levels among enterprises. Technological innovation presents unbalanced development, and the value of 0 accounts for a relatively large proportion. In the type of enterprise technological innovation, the mean value of green technology innovation (LNGPA) accounts for 89.90 of the mean value of enterprise technological innovation, indicating that green technology innovation has gradually become a vital innovation strategic arrangement for enterprises. The average green coverage rate of urban built-up areas is 41.8604, and the median is 42, indicating that the level of urban greening construction in China is relatively high. Among the continuous variables that reflect the characteristics of enterprises, there are extreme outliers in the return on equity of enterprises (ROE), the number of which is 194, accounting for 0.3% of the total sample, accounting for a relatively small proportion.

4. Empirical Results and Analysis

4.1 Benchmark regression results and analysis

By comparing the estimated findings in columns (1) to (3) of Table 3, we can see that adopting high-dimensional fixed-effect regression and clustering the robust standard error to the industry is necessary. This is because when just individual fixed-effect regression is utilized, the R-squared is low, and the constant coefficient is not statistically significant. The R-squared increases after high-dimensional fixed-effect regression, and the constant term is significant. From the regression results in columns (4) to (6) of Table 3, it can be seen that the R-squared value and the regression coefficient of the core explanatory variable (UGC) continue to increase after the control variables are gradually added, indicating that the addition of the main control variables in the benchmark regression is appropriate. Overall, whether the control variable is included or not, the regression coefficient of the core explanatory variable (UGC) to the explained variable (LNPA) is significantly positive, indicating that urban greening plays a positive role in promoting enterprise technological innovation, that is, as urban greening improves, the level of enterprise technological innovation increases significantly. This result validates Hypothesis 1.

Table 3: Benchmark regression results

Variables	The interpreted variable LNPA					
	(1)	(2)	(3)	(4)	(5)	(6)
UGC	0.0055*** (0.0007)	0.0016** (0.0007)	0.0016** (0.0007)	0.0018*** (0.0006)	0.0024*** (0.0008)	0.0025*** (0.0008)
LNA				0.0658*** (0.0130)	0.0656*** (0.0154)	0.0649*** (0.0156)
ROE				−0.00001*** (0.000002)	−0.00001*** (0.000002)	−0.00001*** (0.000002)
GAP				0.0603** (0.0295)	0.0234 (0.0308)	0.0224 (0.0322)
LNOSI					−0.00003 (0.0011)	0.0003 (0.0011)
LNSG					0.0017** (0.0007)	0.0018** (0.0007)
RGDP						0.2129*** (0.0407)
FRG						0.0264 (0.0434)
Constant	−0.0379 (0.0298)	0.0878*** (0.0069)	0.0878*** (0.0048)	−1.2692*** (0.2738)	−1.2602*** (0.3269)	−1.2731*** (0.3245)
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	No	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	industry	industry	industry	industry
Observations	55068	55128	55128	44165	26960	26658
R-squared	0.0016	0.0413	0.0413	0.0464	0.0506	0.0514

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

Furthermore, the control variables that reflect the characteristics of cities and businesses significantly affect the technological innovation of businesses. Among these are the RGDP, which reflects the level of regional economic development, the LNA, which reflects the scale of enterprise assets, and the LNSG, which reflects the level of enterprise environmental protection investment. They have a significant positive impact on enterprise technological innovation because regions with higher economic development levels have more incentive investment in enterprise technological innovation. Enterprises with more significant assets have more strength to carry out technological innovation, and a more extensive environmental protection investment scale can also provide great support for enterprise green technology innovation. The ROE has a significant negative influence, possibly due to the limits of ROE indicators in determining enterprises' capital utilization efficiency.

4.2 Robustness tests

According to the descriptive statistical results of variables (Table 2), considering that the explained variable (LNPA) contains a large number of 0 values, we first used the zero-inflated Poisson regression to test the robustness of the benchmark estimate results. The results are shown in column (1) of Table 4. At the same time, we also found that the values of the number of enterprise patent applications (LNPA) were all greater than or equal to 0, which was in line with the "left truncation" feature. However, the third quartile of LNPA is still 0, the left truncation regression results are not convincing, and the standard deviation of LNPA is much higher than its expected value, which is characterized by over-dispersion. Therefore, the negative binomial regression was used to estimate the benchmark Equation (1) again, the results are shown in column (2) of Table 4. Next, because the individual fixed effects can only control the influence of unpredictable factors that do not change with time on the enterprise's technological innovation capability, they cannot effectively control the influence of those unpredictable factors that change with time. Therefore, in order to mitigate the influence of the above possible missing variables, the interaction terms *Firm*Year* between the enterprise and the year and the interaction term *City*Year* between the city and the year are set, while adding Equation (1) for regression, and the results are shown in column (3) of Table 4. Then, since some extreme outliers will inevitably appear in the continuous variables that reflect the characteristics of cities and enterprises, which may cause specific interference with the baseline estimation results, we will carry out a 5% tail reduction treatment for all continuous variables, and re-regression according to the baseline Equation (1) to eliminate the possible influence of extreme outliers. The results are shown in column (4) of Table 4.

Table 4: Summary of robustness test results

Variables	ZIP	Negative binomial	Joint fixation effect	5% Tail reduction	2013-2020	DPA
	(1)	(2)	(3)	(4)	(5)	(6)
UGC	0.0178*** (0.0033)	0.0182*** (0.0036)	0.0025*** (0.0008)	0.0015** (0.0006)	0.0036*** (0.0012)	0.0011* (0.0006)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−9.183*** (0.2572)	−10.6466*** (0.3007)	8.5976** (3.7156)	−0.7583*** (0.1905)	−1.4190*** (0.3202)	−0.6582*** (0.1215)
Firm-Year	Yes	Yes	Yes	Yes	Yes	Yes
Firm*year City*year	No	No	Yes	No	No	No
Cluster	No	No	industry	industry	industry	industry
	26658	26658	26658	26658	19764	26658
R-squared	No	0.0659	0.0517	0.0503	0.0492	0.0459

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

Furthermore, in order to verify whether the promotion effect of urban greening construction on enterprise technological innovation is robust in different study periods, we replace the total sample from 2009 to 2020 with a sub-sample from 2013 to 2020, and re-regression is conducted according to the baseline regression Equation (1). The results are shown in column (5) of Table 4. Finally, to further enhance the explanatory ability of explanatory variables, a newly explained variable, DPA, is defined to measure the willingness of enterprise technological innovation according to whether it applies to patents. The newly explained variable DPA is substituted into the regression benchmark Equation (1). The results are shown in column (6) of Table 4.

The robustness test results in Table 4 show that the regression coefficient of the core explanatory variable (UGC) is consistently significantly positive, regardless of changing the estimation method, transforming the sample, adjusting the data or redefining the explained variable. This suggests that urban greening construction can significantly improve the technological innovation ability of enterprises, which once again verifies Hypothesis 1, and also shows that the baseline regression results are robust.

4.3 Endogenous test results and analysis

Reverse causality, missing variables and interference of common factors may all cause endogeneity problems. Among them, reverse causality can be eliminated by instrumental variable regression, interference of common factors can be mitigated by delayed regression, missing influence of unpredictable factors can be controlled by fixed effects at all levels, and missing influence of measurable factors can be controlled by increasing control variables. Because of that, we conducted endogenous tests by adding control variables, delayed regression, and instrumental variable regression to further alleviate or eliminate the interference of endogenous factors to verify the correctness of the baseline estimation results.

Considering that financing constraints are an essential factor affecting enterprises' technological innovation, and that the scale of government subsidies can reflect the strength of enterprises' access to external financing support, the industry gross margin reflects the competitiveness of enterprises to a certain extent, and it is also the basis for enterprises' external financing. Therefore, we first add the government subsidy scale indicator (LNGS) to Equation (1) and then add the industry gross margin indicator (IGP) to deal with problems from possible missing variables; the outcomes are displayed in columns (1) and (2) of Table 5. In addition, the impact of urban greening construction on the technological innovation of enterprises may have a specific lag effect, and the scale of urban greening and the level of technological innovation of enterprises may also be affected by some common factors, such as industrial structure, economic development level, etc. Consequently, we add LUGC, the lag term of the green coverage rate of urban built-up areas (UGC), to the reference equation and re-regression. The results are shown in column (3). Finally, indicators such as LUGC, road and bridge area rate (RBR) and average annual precipitation (YRQ) are used as instrumental variables for urban greening construction, and the iv-2sls method was used for regression estimation. Columns (4) to (6) of Table 5 give the second-stage regression results of the three instrumental variables.

Table 5: Summary of endogenous test results

Variable	The interpreted variable LNPA					
	Add control variables		Lag regression	IV1-LUGC	IV2-RBR	IV3-YRQ
	(1)	(2)	(3)	(4)	(5)	(6)
UGC/LUGC	0.0036*** (0.0008)	0.0037*** (0.0008)	0.0051*** (0.0011)	0.0056*** (0.0013)	0.0165*** (0.0044)	0.0421** (0.0192)
CV	Yes	Yes	Yes	Yes	Yes	Yes
LNGS	0.0019 (0.0013)	0.0020 (0.0014)	0.0020 (0.0014)	0.0020 (0.0014)	0.0020 (0.0014)	0.0034*** (0.0009)
IGP		0.0053 (0.0038)	0.0053 (0.0038)	0.0053 (0.0038)	0.0055 (0.0038)	−0.0081* (0.0042)
Constant	−1.2672*** (0.3692)	−1.4299*** (0.3718)	−1.4268*** (0.3751)	−1.4299*** (0.3718)	−1.4193*** (0.3850)	1.2483*** (0.3919)
Firm-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	industry	industry	industry	industry	industry	industry
Anderson LM				6465.348	217.727	45.916
C-D Wald F				9434.693	219.955	45.996
Observations	23731	23697	23697	23697	23697	23697
R-squared	0.0545	0.0549	0.0553	0.0818	0.0701	0.0088

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

Moreover, the Anderson LM test statistics of the three instrumental variables are 6465.348, 217.727, and 45.916, respectively, and they are all significant at the 1% level, indicating that their instrumental variables have no problem with insufficient recognition. The statistical values 9434.693, 219.955, and 45.996 of Cragg-Donald Wald F are also much more higher than the tolerable critical value 16.38 of the Stock-Yogo weak instrumental variable recognition F test at the 10% level, rejecting the null hypothesis of the existence of weak instrumental variables. It shows that the three instrumental variables have validity.

The results indicate that the regression coefficient of the primary explanatory variable (UGC) to enterprise technological innovation (LNPA) is consistently significantly positive, regardless of whether the control variable is included, the lag regression method is employed, or the tool variable method is employed. These results again demonstrate that urban greening construction can considerably enhance the technical innovation of enterprises and reaffirms the validity of the benchmark regression results.

4.4 Extensibility analysis: heterogeneity test

4.4.1 Tests based on regional, industry, and firm heterogeneity

Furthermore, funds for urban greening construction mainly come from local public financial revenue, closely related to the level of urban economic development. However, there is a significant difference in the level of economic development between the eastern coastal areas and the central and western areas of China. Will this regional difference significantly affect the enterprise technological innovation effect of urban greening construction? In addition, will the difference in environmental regulatory pressures faced by heavy-polluting and other industries also affect the role of urban greening construction on enterprise technological innovation? Moreover, will the differences in resource endowment and policy compliance of different ownership types affect the enterprise technological innovation effect of urban greening construction?

In order to answer these questions, this part will introduce binary dummy variables that describe the differences of region, industry and ownership type and test and analyse them by grouping regression according to the setting of the benchmark regression Equation (1) to better understand the heterogeneous relationship between urban greening construction and enterprise technological innovation. Specifically, if the city is under the jurisdiction of the eastern provinces, municipalities and autonomous regions of China, it is called an eastern city, and the value is 1; otherwise, it is a central and western city, and the value is 0. Similarly, the "Listed Enterprises Environmental Verification Industry Classification Management List" published by the Ministry of Environmental Protection of China in 2008, contains a definition of heavy pollution industries, where the mining industry, textile and clothing fur industry, metal and non-metal industry, petrochemical plastics industry, food and beverage industry, water and gas industry, biomedical industry and paper printing industry are defined as heavy pollution industries. These are given the value of 1, and other industries are 0. Similarly, the value of state-owned enterprises is 1, and that of private enterprises is 0. The regression results are shown in Table 6.

Table 6: Test results of region, industry, and firm heterogeneity

Variables	Regional differences		Industry differences		Ownership differences	
	Eastern	The Midwest	Heavy pollution	Others	State-owned	Private
	(1)	(2)	(3)	(4)	(5)	(6)
UGC	0.0058*** (0.0012)	−0.0003 (0.0006)	0.0025** (0.0006)	0.0027 (0.0016)	0.0054*** (0.0013)	0.0019* (0.0009)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−1.2104*** (0.3299)	−1.4095*** (0.3478)	−1.6952*** (0.1661)	−0.7545* (0.4226)	−1.4745* (0.7256)	−1.2448*** (0.2926)
Firm-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	industry	industry	industry	industry	industry	industry
Observations	19547	7111	19274	7384	8772	15269
R-squared	0.0769	0.0967	0.0845	0.0148	0.1203	0.0729
Empirical p-Values	−0.006***		−0.004***		−0.003*	

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

From the regression results in columns (1) to (6) of Table 6, the effect of urban greening construction on enterprise technological innovation in Eastern China is more significant, and the effect on enterprise technological innovation in Central and Western China is negative but not significant. At the same time, the impact on enterprise technological innovation in polluting industries is significantly positive. However, it is favourable but insignificant for other industries, and the promotion effect on technological innovation of state-owned enterprises is greater than that on private enterprises. This shows that the financial support of local governments, the pressure of corporate environmental governance and the intensity of corporate policy compliance can further enhance the promotion role of urban greening construction in corporate technological innovation. At the same time, considering that it is difficult to directly compare the regression results of the two groups with inconsistent samples, a permutation test was carried out for different groups; that is, the empirical p-values were obtained by self-sampling 1000 times under different circumstances. The results show that the empirical p-values of different groups are significant, verifying the accuracy of the above conclusions.

4.4.2 Heterogeneity test based on patent application type

The above analysis confirms that urban greening construction can promote technological innovation of enterprises, that is, increase the number of patent applications of enterprises. Nonetheless, enterprise patents can be categorized as green patents, invention patents, utility models and design patents. Then, does urban greening construction have a heterogeneous effect on different types of patent applications?

We examine the differential influence of the green coverage rate of urban built-up areas (UGC) on enterprise technological innovation (LNGPA), LNFM, and LNXW according to Equation (1). In addition, to guarantee the robustness of the estimation results, we conduct additional estimations by using DGPA, DFM and DXW as the explanatory variables according to the setting of Equation (1). If an enterprise filed for a green patent, an invention patent, a utility model and a design patent in the year *t*, the value is 1; otherwise, it is 0. This is recorded as DGPA, DFM and DXW, respectively; see Table 7 for the results.

Table 7: Test results of the heterogeneity of patent application types

Variable	Green innovation		Invention		Utility and Design	
	LNGPA	DGPA	LNFM	DFM	LNXW	DXW
	(1)	(2)	(3)	(4)	(5)	(6)
UGC	0.0016*** (0.0004)	0.0006** (0.0002)	0.0015* (0.0008)	0.0007*** (0.0002)	0.0009 (0.0006)	0.0004 (0.0003)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.6808*** (0.3344)	0.8124*** (0.1756)	0.9933*** (0.2790)	0.6073*** (0.1542)	0.9511*** (0.1764)	0.4902*** (0.0932)
Firm-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	industry	industry	industry	industry	industry	industry
Observations	26658	26658	26658	26658	26658	26658
R-squared	0.0670	0.0636	0.0477	0.0505	0.0441	0.0498

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

From the regression results in columns (1) to (6) of Table 7, it can be seen that urban greening construction has a more significant effect on increasing the number of green patents and invention patents applied by enterprises. In contrast, it has no significant effect on increasing the number of utility models and design patents. Urban greening construction can improve the technological innovation ability of enterprises by increasing the number of green patents and invention patents, which provides a reference for local governments to strengthen urban greening construction and promote the technological innovation of enterprises.

5. Mechanism Test and Discussion

The above empirical analysis shows that in Equation (1), the regression coefficient of the green coverage rate of urban built-up areas (UGC) to the enterprise technological innovation (LNPA) is significantly positive, meeting the preconditions for the test of intermediary effect and moderating effect. Therefore, this part focuses on testing the intermediary effect models (2), (3)., and the moderating effect model (4).

5.1 Mediation effect test results and analysis

According to the setting of intermediary effect models (2) and (3), following the intermediary effect test procedure, Equation (2) is tested first, then Equation (3). Suppose the coefficients γ_1 and δ_1 , δ_2 are significantly positive. In that case, part of the intermediary effect of enterprise environmental responsibility undertaking, urban human capital enhancement and urban air quality improvement on urban greening construction promoting enterprise technological innovation will be established. Table 8 reports the test results of the mediating effects of the corporate environmental responsibility undertaking mechanism, regional human capital improvement mechanism and regional air quality improvement mechanism.

Table 8: Test results of mediation effect

Variables	Environmental Responsibility Undertaking		Human Capital Improvement		air quality improvement	
	EER	LNPA	UHD	LNPA	UAQ	LNPA
	(1)	(2)	(1)	(2)	(5)	(6)
UGC	0.0041*** (0.0017)	0.0117*** (0.0039)	0.0047*** (0.0012)	0.0016*** (0.0005)	0.0635*** (0.0149)	0.0018*** (0.0004)
EER		0.0048* (0.0026)				
UHD				0.0335*** (0.0117)		
UAQ						0.4728** (0.2056)
CV	Yes	Yes	Yes	Yes	Yes	Yes
Constant	6.8381*** (0.4099)	−4.7442*** (0.9599)	3.1624*** (0.3126)	1.8860*** (0.5871)	−53.365*** (1.8469)	2.0218*** (0.6287)
Firm-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	industry	industry	industry	industry	industry	industry
Observations	26658	26658	23697	23697	23697	23697
R-squared	0.4799	No	0.0853	0.0659	0.7543	0.0656

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

5.1.1 Enterprise environmental responsibility undertaking mechanism test

The 0 value in the LNPA data sample accounted for about 8% of the total sample. The 0 value in the corporate environmental responsibility score (EER) accounted for about 57.4% of the total sample, and its mean value (37.7578) and standard deviation (36.2337) were equal. Therefore, when corporate environmental responsibility (EER) is the explained variable, it is suitable to adopt Poisson regression in the regression of the intermediary effect test Equation (2), and zero-inflated Poisson regression is adopted in the regression of the intermediary effect test

Equation (3) when the enterprise technological innovation is the explained variable. The test results are shown in columns (1) and (2) of Table 8.

According to the regression results in columns (1) and (2) of Table 8, the regression coefficients of urban greening construction (UGC) to enterprise environmental responsibility undertaking (EER) to the explained variables (LNPA) are significantly positive, that is, the coefficients γ_1 and δ_1, δ_2 are significantly positive. Furthermore, the regression coefficient value of UGC to LNPA is 0.0117, less than the coefficient value of 0.0118 (column (2) of Table 4). This shows that the enterprise environmental responsibility undertaking mechanism plays a part of the intermediary role in the promotion of enterprise technological innovation by urban greening construction; that is to say, enterprise environmental responsibility undertaking is an intermediary mechanism for urban greening construction to promote enterprise technological innovation, which verifies Hypothesis 2.

5.1.2 Urban human capital enhancement mechanism test

According to the regression results in columns (3) and (4) of Table 8, the regression coefficients of urban greening construction (UGC), urban human capital (UHD), the explained variables (LNPA) are significantly positive, that is, the coefficients γ_1 and δ_1, δ_2 are significantly positive. Moreover, the regression coefficient value of UGC to LNPA is 0.0016, which is less than the coefficient value (0.0025) of the baseline estimate result (column (6) of Table 3). This shows that the urban human capital improvement mechanism plays a part of the intermediary role in the promotion of enterprise technological innovation by urban greening construction; that is to say, urban human capital enhancement is an intermediary mechanism for urban greening construction to promote enterprise technological innovation, which verifies Hypothesis 3.

5.1.3 Urban air quality improvement mechanism test

As the proxy variable for urban air quality, the per capita PM2.5 concentration index is a negative indicator; the lower the index value, the better the urban air quality. In order to better comprehend the mediation effect test results, we normalized the index before running the test.

It can be seen from the results in columns (5) and (6) of Table 8 that the coefficients of urban greening construction (UGC) to urban air quality (UAQ) to the explained variable (LNPA) are significantly positive, that is to say, the coefficients γ_1 and δ_1, δ_2 are significantly positive. In addition, the regression coefficient value of UGC to LNPA is 0.0018, which is less than the coefficient value (0.0025) of the baseline estimate result (column (6) of Table 3). This indicates that the urban air quality improvement mechanism plays a partial intermediary role in the promotion of enterprise technological innovation by urban greening construction, this means that urban air quality improvement is an intermediary mechanism for urban greening construction to promote enterprise technological innovation, which verifies Hypothesis 4.

5.2 Test results and analysis of moderating effect

By the setting of the moderating effect test Equation (4), this section focuses on testing the direction and significance level of the regression coefficient of the interaction term (UGC * MCP) to the explained variable (LNPA) to verify whether the promotion of the marketability process plays a positive moderating role in promoting enterprise technology innovation in urban greening construction. In order to enhance the reliability of the regulatory effect test results, multiple regression analysis methods are used in Table 9 further to test the robustness and endogenous interference of the moderating effect.

Table 9: Test results of the moderating effect of urban marketability process

Variable	The interpreted variable LNPA					
	Without CV	CV	2011–2020	DPA	IV1—RBR	IV2—YRQ
	(1)	(2)	(3)	(4)	(5)	(6)
UGC*MCP	0.00006* (0.00003)	0.0002** (0.0001)	0.0007* (0.0004)	0.0001*** (0.00003)	0.0070** (0.0033)	0.0003*** (0.0001)
MCP	−0.0035 (0.0066)	0.0002 (0.0061)	0.0034 (0.0066)	0.0007 (0.0025)	−0.0621 (0.0285)	−0.0008 (0.0060)
UGC	0.0018** (0.0007)	0.0027*** (0.0008)	0.0033*** (0.0009)	0.0012* (0.0006)	0.0568*** (0.0203)	0.0041*** (0.0012)
CV	No	Yes	Yes	Yes	Yes	Yes
Constant	0.1124*** (0.0573)	−1.2964*** (0.3377)	−1.4179*** (0.3400)	−0.6760*** (0.1241)	−1.3368*** (0.4081)	−1.2925*** (0.3392)
Firm-Year-City	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	industry	industry	industry	industry	industry	industry
Observations	55068	26658	23350	26658	26658	26658
R-squared	0.0413	0.0813	0.0993	0.0599	0.0246	0.0821

Notes: the brackets are the robust standard errors of coefficients. * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively

Source: authors' calculations

The outcomes of testing the moderating effect of the marketability process on urban greening construction to foster enterprise technical innovation are presented in Table 9. According to the results in columns (1) to (6), the regression coefficient of the core explanatory variable (UGC*MCP) to the explained variable (LNPA) is consistently significantly positive, regardless of the estimation method. This demonstrates that promotion of the marketability process can play a positive role in strengthening urban greening construction to promote enterprise technology innovation, and this result has passed the robustness and endogenous tests, validating Hypothesis 5.

6. Conclusion and Recommendations

Using data for Chinese cities and listed enterprises from 2009 to 2020 as samples, we empirically examined the impact of urban greening construction on enterprise technology innovation. The research results demonstrate that urban greening construction considerably promotes the technological innovation of enterprises; this conclusion is still robust after various robustness tests and endogenous processing. The results of heterogeneity analysis show that compared with the Central and Western regions, urban greening construction has a more significant promoting effect on the technological innovation of enterprises in the economically developed Eastern Region; compared with other industries, urban greening construction has a more obvious promoting effect on the technological innovation of enterprises in heavily polluting industries; compared with private enterprises, urban greening construction has a better effect on the technological innovation of state-owned enterprises. At the same time, urban greening construction has a significant promotion effect on enterprise invention and green patent applications. However, it has no significant promotion effect on utility models and design patent applications. The mechanism test results show that urban greening construction mainly enhances the technological innovation capability of enterprises by strengthening corporate environmental responsibility undertaking, enhancing urban human capital and improving urban air quality, and the advancement of the urban market process significantly enhances the promotion effect of urban greening construction on technological innovation of enterprises.

In response to these findings, this research draws the following policy implications. Firstly, we should continue to strengthen urban greening construction, enhance the regional green coverage rate, improve air quality, actively mobilize regional high-quality resources to enhance regional advantages and improve the agglomeration scale of human capital and high-tech industries. Secondly, we should increase the publicity of urban greening construction, raise the attention of the public, media and government to the urban environment, force enterprises to strengthen environmental responsibility undertaking, guide enterprises in the east, state-owned enterprises, and heavily polluting enterprises to actively carry out green innovation strategies, and form a demonstration effect to drive enterprises in the central and western regions, private enterprises and enterprises in lightly polluting industries to accelerate technological innovation. Thirdly, the process of urban marketability should be accelerated, especially at the management level of investment funds in urban greening construction, and the ability of market-oriented reform should be improved to solve the problem of widespread government failure in urban greening construction.

In addition, the limitations of this research deserve further study. Firstly, the impact of the "crowding out" effect of urban greening construction investment on corporate environmental and R&D investment on corporate technological innovation has not been analysed. Secondly, the influence of the synergistic adjustment between urban greening construction and other environmental regulation means on enterprise technological innovation needs to be considered. Thirdly, with the development of China's digital economy and the implementation of green finance rules, urban greening construction and its coordinated development will also significantly affect enterprises' production and investment behaviour. Therefore, future research can be supplemented by the above three aspects.

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