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Article

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Multi-dimensional competition in local governments, performance pressures, and corporate green innovation in China

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ABSTRACT

Based on the panel data of China's listed companies from 2009 to 2020, this paper examines the relationship between multi-dimensional competition among local governments and corporate green innovation. It also investigates the influencing mechanism of performance pressures in this relationship. The results show that (1) Government competition with different motives has heterogeneous effects on green innovation. Growth and fiscal competition negatively affect green innovation, while investment attraction and regulation competition significantly positively affect green innovation. (2) The performance pressure significantly reduces the negative effect of fiscal competition and enhances the positive effect of investment attraction and regulation competition. (3) The regional heterogeneity analysis shows that investment attraction competition positively affects green innovation in the eastern, central, and western regions. While the impact of growth and fiscal competition in the eastern region is insignificant, the former is significantly negative in the central and western regions.

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Local government; multi-dimensional competition; green innovation; performance pressures

1. Introduction

In 2020, China proposed the strategic target of carbon peak and neutrality at the 75th United Nations General Assembly, highlighting China's determination for green and high-quality development (F. J. Xu et al., 2020). It provided direction for economic recovery after the epidemic and increased corporate green innovation requirements. In 2022, the 20th National Congress of the Communist Party of China emphasized that innovation was the primary driving force for economic development. It also proposed coordinating the promotion of carbon reduction, energy saving, and green expansion to promote low-carbon industrial development. Under the dual constraints of resources and the environment, green innovation reflects the requirements of ecological green integration, which is the key to realizing sustainable development (Razzaq et al., 2022;

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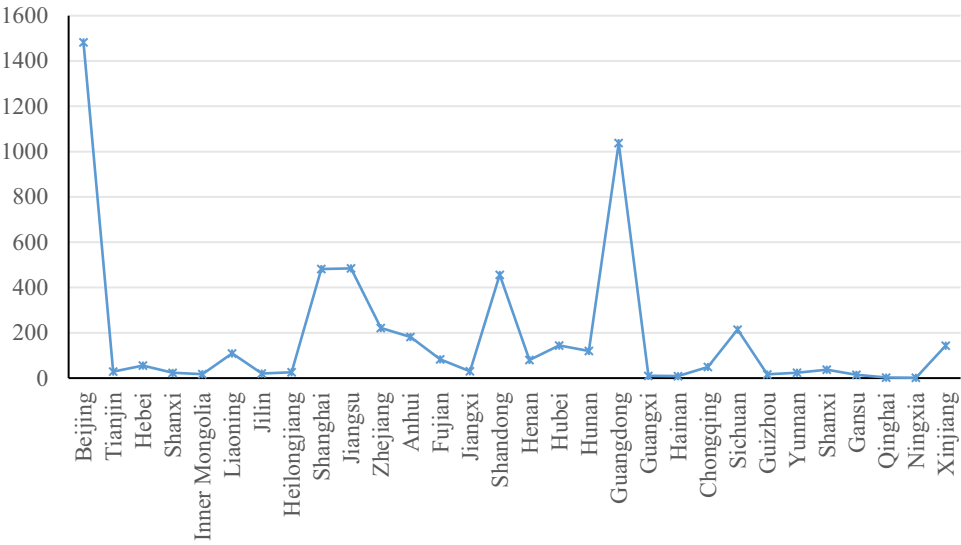


Figure 1. Distribution of green patent applications in China. The annual average of green patent applications by A-share listed companies in Shenzhen and Shanghai from 2009 to 2020 are statistically analyzed. Tibet is not included due to the data availability.

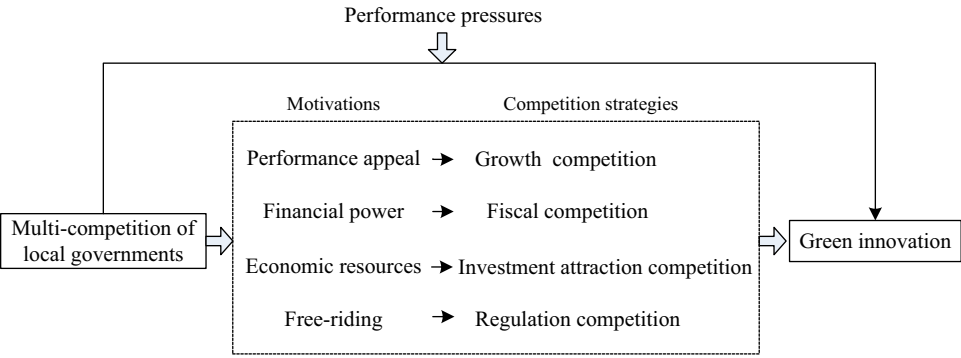


Figure 2. Framework of multi-dimensional competition of local government, performance pressures, and green innovation of enterprises.

M. Song et al., 2019). In recent years, the distribution of green patent applications in various regions of China is shown in Figure 1.

Significant differences exist in green patent applications in different regions, presenting an imbalanced development characteristic. The reasons may include the differences in innovation foundation, resource endowment, and technology accumulation among regions (Iqbal et al., 2022). The geographical advantage is also an essential factor affecting the spatial flow of green innovation factors, which helps the diffusion of green technology and the spillover of talents and knowledge (L. N. Ma et al., 2023). The eastern and coastal cities, such as Beijing, Guangdong, Jiangsu, and Shandong, are the most active areas for innovation activities. Due to the spatial positive externality of green innovation activities, local governments must provide

guidance and support. Through policies of finance, taxation, and environmental regulations, local governments can conduct macro-control on talents, capital, technology, etc (Breton, 1998; L. N. Ma et al., 2022). It helps solve the problems of distorted resource allocation and market inefficiency, which effectively improves the supply quality of public goods. As the leading force of green innovation activities (Arrow, 1971), local governments form a championship-type competition pattern for economic growth and political promotion driven by the centralized political system. The essence of their competition is to catch up with developed economies and promote green innovation activities.

In recent years, the relationship between local governments' macro-behavior and enterprises' micro-innovation has become a hot issue in academic research (L. N. Ma et al., 2023). Many scholars have studied the impact of government competition on innovation activities, financial subsidies, and green development (Bernholz & Vaubel, 2006; Mansfield & Switzer, 2017; Nie et al., 2022; Wu et al., 2020). However, these studies mainly focus on a single dimension (Deng et al., 2019), including innovation for growth and competition. The former mainly manifests as local government competition centered on economic growth, which affects corporate green innovation. For a long time, the political promotion of local officials has been mainly based on their contribution to economic growth performance. It is linked to regional economic development (H. B. Li & Zhou, 2005), resulting in competition for high-quality production factors and economic resources. The latter is innovation-oriented local government competition, where governments continuously strengthen their support and investment in green innovation. If local areas take no positive measures, it will lead to the outflow of talent and resources.

From the perspective of fiscal decentralization, existing studies often use local government competition to explain regional economic development (L. G. Qin et al., 2023; M. Xu, 2022; Zhao et al., 2022), with less involvement in explaining green innovation. The relationship between local government competition and green innovation has not yet formed a unified conclusion, and the relevant theoretical framework has not been constructed. Local government competition is a comprehensive competition regarding resources, political achievements, and policies. Driven by different competitive motives, its impact on green innovation may be multi-faceted. Whether there are significant differences in the impact of local government competition on green innovation across different dimensions requires empirical testing within a systematic analytical framework. However, only a few existing studies have been conducted from the perspective of multi-dimensional competition of local governments. Further investigation is needed to determine which dimension of local government competition will produce a stronger innovation incentive effect. Therefore, a more systematic and comprehensive study helps solve specific problems, such as the low-carbon development path.

Besides, the competitive behavior of local governments is closely related to performance pressure faced by officials, which is generated by achieving the performance goals set by the central or higher-level governments. Under the centralized political model in China, the central and superior governments have the decision-making power to evaluate and promote lower-level government officials. This top-down bureaucratic system promotes the promotion incentive mechanism for local officials, thus putting pressure on political performance. To achieve political goals and obtain favorable political promotion opportunities, local officials must work harder during their tenure, sometimes at the

expense of economic quality. Does the performance pressure induce strategic interaction between regions, leading to “race-to-bottom” competition and green paradox in green innovation, or promote the pursuit of high-quality liquidity factors, leading to “race-to-top” competition? This is an important practical issue that deserves attention.

In 2007, the State Council in China issued a notice on the comprehensive energy conservation and emission reduction work plan. It mentioned that the above index would be included in the government assessment system, directly affecting the direction and intensity of government competition. In 2013, the Organization Department of the CPC Central Committee issued a notice on improving the performance assessment of government officials, resulting in a fundamental change in the evaluation criterion.¹ The GDP growth rate was no longer the only criterion in China, and environmental governance became an essential part of government competition. Since then, the growth competition and fiscal competition have declined, and the high-quality investment attraction competition and regulation competition have been constantly enhanced. Due to the implementation of new performance evaluation standards, the effect of local governments’ multi-dimensional competition on corporate green innovation may be significantly changed.

Few studies examine the relationship between multi-dimensional competition and green innovation from the perspective of performance pressures. Relevant literature mainly focuses on theoretical exploration and paradigm analysis, and its internal mechanism needs further testing. Local governments have high rights over regional development, and the performance pressure affects their competition dimension and intensity. Then, it affects the business decision-making in firms within their jurisdiction (Jones & Olken, 2005). We can only accurately explore the deep-seated reasons that affect green innovation by incorporating performance pressure, local government competition, and green innovation into the same research framework. This provides a new opportunity, so this paper studies their relationship based on the multi-government competition perspective, including growth competition, fiscal competition, investment attraction competition, and regulation competition. The performance pressure is also incorporated into the framework to explore its internal mechanism.

The study contributes to the literature in the following ways: First, the systematic theoretical analysis framework is constructed, and local governments’ heterogeneous effects of multi-dimensional competition on green innovation are investigated. The symmetric multi-winner tournament model is applied to study the relationship between macro government behavior and micro innovation of firms. It breaks the research boundary of traditional green innovation, which enriches the innovation theory and political tournament theory. Second, the unique institutional background of fiscal decentralization in China is considered, and the performance pressure is included in the research framework, providing a new perspective for the study of green innovation. It further enriches the research scope of related issues, which can more accurately capture and understand the deep causes of the green patent phenomenon. That will help explore the external institutional reasons that cause enterprises to fall into low-end technology lock and reveal how local government behaviors affect green innovation activities.

¹<https://news.12371.cn/2013/12/09/ARTI1386590057904551.shtml>

2. Literature review and research hypothesis

2.1. *Multi-dimensional competition in local governments and green innovation*

The multi-dimensional competition involves vertical competition at different levels of central and local governments, horizontal competition in different regions at the same level, and pre- and post-competition in various periods in the same region. Seen from the competition content refers to the competition in the economy, finance, system, resource elements, etc. According to the promotion tournament theory, there are self-interested motives in local governments, including the race led by economic growth, the investment quality race in the bottom line, the competition for fiscal power, the optional choice of environmental regulation, etc (Wu et al., 2020; Zavadskaya & Shilov, 2021; J. Zhang et al., 2021). All the above can be concluded as growth competition, fiscal competition, investment attraction competition, and regulation competition. Strategic interaction in the competition process among local governments exerts spillover effects by competing to cut tax rates, increase fiscal expenditure, and relax environmental policies (Case et al., 1993; Woods, 2006; Zodrow & Mieszkowski, 1986). Motivated to score high in this competition, officials obtain relative performance (Maskin et al., 2000; C. Xu, 2011), affecting corporate green innovation.

The existing research explores the relationship between local government competition and innovation activities, but it mainly focuses on the competition represented by economic growth rate. No unified conclusions have been reached. As green innovation is an economic public good with production attributes, local governments may have self-interested motives when guiding enterprise innovation, resulting in a robust competitive response (Nie et al., 2022). So, some scholars believe that local government competition can promote green innovation by improving the allocation of public financial resources (Luca & Atuahene, 2007). Local governments often provide financial support and preferential tax policies to expand fiscal expenditure further, releasing macro-government regulation signals. It facilitates firms' strategic choices for green innovation and R&D investment and promotes the flow of social capital and production factors. The concentration of high-end factors such as talents, knowledge, financial capital, and FDI mitigates resource constraints and stimulates innovation motivation (Sovacool et al., 2022).

As the leading force of green innovation, local governments prefer to formulate industrial and environmental policies to obtain better performance appraisals. However, the political goals and environmental governance tasks are transferred to firms within the jurisdiction because of their purpose of maintaining good political relations. Additionally, some firms may be motivated to "seek support," forming a strategic green innovation behavior (Dosi et al., 2006; Hall & Harhoff, 2012). When managers expect to receive more government subsidies or tax incentives, they will invest in green innovation to convey positive signals to the market and satisfy the requirements of government policies.

However, some scholars believe that under the dual constraints of resources and environment, problems such as regional differentiation, local protection, distorted fiscal structure, and environmental damage caused by government competition have become increasingly prominent (Y. Xu et al., 2022; Yan et al., 2022). For a long time, local governments, encouraged by economic catch-up and political promotion, have formed a growth and promotion-oriented policy preference. They prefer infrastructure projects

with fast investment returns and low risk in the allocation of public resources (Wang et al., 2022). However, green innovation activities are often ignored because of the long periodicity, high capital demand, and associated risks. It further intensifies local governments' self-serving investment behavior focusing on production but not innovation (L. Yang et al., 2022). Additionally, local governments' administrative and resource allocation power may be exercised to intervene in business activities. The one-sided pursuit of regional economic growth at the cost of relaxing environmental regulations triggers the discontinuity of regulation policies and the "race-to-bottom" competition (Bu & Wagner, 2016; J. Zhang et al., 2020).

Because of environmental governance's positive externalities and pollution transmission's negative externalities, local governments have a "free-riding behavior" (W. Zhang et al., 2010). It results in protectionism against local backward enterprises and barriers to prevent technology spillovers, breeds green innovation inertia, and even opportunistic behaviors, such as power rent-seeking. All these inhibit the improvement of green innovation quality. Therefore, local governments' different competitive motives may lead to heterogeneous effects on green innovation. However, few studies have classified and explored the relationship between the multi-dimensional competition of local governments and corporate green innovation. This paper proposes the following competitive hypotheses:

Hypothesis 1: Growth competition in local governments has a positive/negative impact on corporate green innovation.

Hypothesis 2: Financial competition in local governments has a positive/negative impact on corporate green innovation.

Hypothesis 3: Investment attraction competition in local governments has a positive/negative impact on corporate green innovation.

Hypothesis 4: Regulation competition in local governments has a positive/negative impact on corporate green innovation.

2.2. The influence mechanism of performance pressures

In transitional China, the central and local governments have high discretionary power, including administrative approval, preferential policies, loan guarantees, etc. But there is a limit to the benefits of decentralization (Hayakawa et al., 2014). They even have the right to appoint lower-level government officials, resulting in high competition among officials for political promotion. Because of the effects of yardstick competition, promotion tournaments and high pressure on performance assessment are formed (Y. Chen et al., 2005; H. B. Li & Zhou, 2005; Mitchell et al., 2018).

The performance appraisal system with GDP growth has long been implemented in China. Local governments tend to invest critical economic resources in projects that can achieve explicit economic growth during their tenure (Wang et al., 2022; Yan et al., 2022;

L. Yang et al., 2022). Especially in politically sensitive periods, local officials may relax environmental supervision to pursue short-term economic benefits (H. B. Li & Zhou, 2005). So, government competition under high economic achievement pressure has a crowding-out effect on green innovation resources. It even leads to overcapacity and deterioration of the competitive environment (Hsu et al., 2014), inhibiting green innovation improvement. Driven by economic growth, the performance appraisal of local officials has led to incentive distortion. In 2007, the State Council considered energy conservation and emission reduction, and the “one vote veto” and the accountability system were implemented. In 2013, it was required that GDP should not be the only evaluation criterion. The weight of environmental protection, resource consumption, overcapacity digestion, and other comprehensive indicators has increased since then. It directly links local officials’ performance with regional pollutant emissions, which breaks the traditional practice of catching up with the economy (Hong et al., 2019). Local governments began formulating stricter environmental policies, laws, and regulations in the competition (Y. J. Chen et al., 2018; Hottenrott & Rexhäuser, 2015).

After the release of the Notice in 2013, the central government further emphasized the importance of high-quality and green development of the regional economy. In 2015, it established an environmental protection inspection mechanism, clarifying how to hold government leaders accountable for ecological and environmental damage. The annual and five-year evaluation mechanisms for the ecological civilization construction of local governments were further proposed in 2016. And the performance evaluation system was optimized in 2020. So local governments are more motivated to promote environmental construction in competition and allocate economic and administrative resources to green innovation activities. Therefore, the Notice proposed in 2013 is a crucial turning point in the assessment system for local government officials. Firms must make green innovations to reduce the cost of environmental regulations, achieving a competitive advantage (Marconi, 2009).

The change in the performance appraisal system promotes healthy competition among local governments. Under the new achievement pressure, governments have more substantial supervision and restrictions on corporate emissions and innovation activities (Y. Chen et al., 2022). It effectively reduces the short-sighted behavior of overvaluing economic growth (Y. Xu et al., 2022), which affects the relationship between local government competition and green innovation. Based on this, the theoretical research framework of multi-dimensional competition in local government, performance pressures, and green innovation of enterprises is also constructed, as shown in Figure 2.

Hypothesis 5: The new performance appraisal system affects the green innovation effect of local government competition.

3. Research design

3.1. Samples and data sources

This paper selects A-share listed companies in Shenzhen and Shanghai for research samples, and the reasons are as follows. First, Chinese enterprises can be divided into

listed companies and non-listed companies. The former must disclose their financial and operational information publicly, while the latter are not, resulting in poor information transparency. Second, the A-share market in Shanghai and Shenzhen is one of the largest stock markets in China, including numerous listed companies, especially typical industry representatives and leading enterprises. The relatively large market size and relevant data can reflect China's capital market's operation and development status. Given the availability and transparency of the data and the accuracy of information disclosure, such companies are ultimately used for research.

In 2008, China's patent law was revised for the third time. To reduce the deviation of the results caused by the revision of patent law, the selected samples are from 2009 to 2020. The financial enterprises and those with ST and negative net assets are excluded, and 1449 annual observations are finally obtained.

The data are from the National Bureau of Statistics, the State Intellectual Property Office, the World Intellectual Property Organization, the China Statistical Yearbook, the CNRSD (Chinese Research Data Services Platform) database, and the CSMAR (China Security Market and Accounting Research) database. As for samples with missing data, the linear interpolation method is used for calculation (Byzalov & Basu, 2019). All data are Winsorized at 1% to eliminate the interference of outliers or extreme values.

3.2. Definition of variables

3.2.1. Local government competition

This paper examines the innovation effect of local government competition from the following dimensions: growth competition ($Comp_1$), financial competition ($Comp_2$), investment attraction competition ($Comp_3$), and regulation competition ($Comp_4$).

According to Grossman and Hart (1986), Greenstone (2002), H. B. Li and Zhou (2005), Yao and Zhang (2015), and Pu and Fu (2018), growth competition is measured by the GDP growth rate. The better the regional economic development, the greater the probability of local officials' promotion (C. Xu, 2011). The ratio of fiscal expenditure to fiscal income measures fiscal competition. The greater the ratio, the higher the local government fiscal competition intensity. The investment attraction competition is measured by foreign direct investment (FDI) and is treated per capita to eliminate the influence of regional population factors. The regulation competition is mainly about the intensity of environmental regulation, which is measured by pollutant emission reduction rate.

It is worth noting that the investment attraction competition brings about capital accumulation, external management experience, and advanced technology, with technology spillover and import substitution effects. However, in the long-term competition environment centered on GDP growth, the competition for investment attraction mainly manifests in the following forms. The first is factor price discount competition through financial subsidies, tax optimization, and other methods. The second is an institutional discount competition through optimizing the business environment and improving the efficiency of foreign investment management. It aims to transform the advantages of labor, land, and other factors within the jurisdiction into regional taxes and GDP through FDI. This intensifies the factor investment competition, which ultimately shows as the race-to-bottom competition in factor prices (Deng et al., 2019), and even brings the

failure of government regulation (Keen & Kotsogiannis, 2002). While making significant contributions to regional economic growth, the investment attraction competition also needs certain doubts, such as the decline in factor allocation efficiency and the inability to unleash technology spillover effects. For local governments, maximizing external investment is the key to the competition in investment attraction. They introduce a series of policies to actively compete for FDI, especially in the absence of funds. So, this paper uses this index to measure the degree of competition in investment attraction.

3.2.2. *Green innovation*

Patents reflect the technological innovation capability of enterprises (Thi & Do, 2024). The number of green patent applications is selected to measure green innovation (*GI*) by referring to Cornaggia et al. (2015), Z. L. He et al. (2018), and G. Hu et al. (2021). It is obtained by retrieving from the China National Intellectual Property Administration and matched in the green patent IPC classification number launched by the World Intellectual Property Organization. The larger the number of green patent applications, the higher the level of green innovation (L. N. Ma et al., 2023).

3.2.3. *Performance pressures*

The notice of changing the performance evaluation standards for officials in 2013 has caused significant changes in the evaluation indicators. The traditional single evaluation indicator centered on GDP growth has gradually shifted to the sustainable and high-quality development indicator centered on environmental protection. Its weight in the entire evaluation system constantly increases, indicating that government officials face severe environmental evaluation pressure. In addition to pursuing economic growth in local competition, they must consider environmental performance. So, this notice is a crucial turning point in the evaluation system of government officials, which marks the radical change in the precious performance view of GDP and directly affects the competition behavior of local governments. That's why it can be used to measure political performance pressure.

Therefore, this paper notes that improving the performance assessment of government officials issued by the Organization Department of CPC Central Committee in 2013 had an exogenous impact. It fundamentally changes the performance assessment standard of local officials (J. Zhang et al., 2020), transforming from the traditional economic achievement pressure to the green political achievement pressure. The time when the notice is released is taken as the demarcating point to set the variable of performance appraisal (*Pres*), which is used to measure the performance pressure faced by government officials. The year after 2013 is assigned 1; otherwise, it is 0.

3.2.4. *Control variables*

Referring to Amore and Bannedsen (2016) and J. Hu et al. (2020), the firm-level variables are controlled, including firm scale (*Size*), the natural logarithm of total assets; capital structure (*Debt*), the ratio of total liabilities to total assets; cash flow level (*Cash*), the ratio of the net cash flow from operating activities to total assets; capital intensity (*Cap*), the natural logarithm of the ratio of the total fixed assets to the number of employees; enterprise growth (*Grow*), the operating income growth rate; enterprise maturity (*Age*), the natural logarithm of the current year minus the establishment year; the number of

employees (*Labor*), the natural logarithm of employees; property rights (*Prop*), the state-owned enterprise is assigned as 1; otherwise, it is 0; separation of two rights (*Dual*), if one person concurrently holds the chairman and general manager, assign it as 1; otherwise, it is 0. Since local government competition is a provincial indicator, green innovation of enterprises is not only affected by their characteristics but also restricted by the local market environment. So, the regional control variables are added to the model by referring to X. Qin and Sun (2019), Kim et al. (2021), L. Liu et al. (2021), and S. Song et al. (2021). Industrial structure (*Stru*), measured by the ratio of the secondary industry to GDP; population density (*Dens*), measured by the natural logarithm of the ratio of year-end population to regional land areas; opening intensity (*Open*), measured by the ratio of imports and exports to GDP; financial development level (*Fin*), measured by the loan-to-deposit ratio of financial institutions.

3.3. Model construction

The following basic model is constructed to investigate the impact of local governments' multidimensional competition on enterprise green innovation.

$$GI_{it} = \alpha + \beta_1 Comp_{it} + \beta_n Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Where, *GI* refers to green innovation of enterprises; *Comp* is a multi-dimensional competition of local governments, including growth competition, fiscal competition, investment attraction competition, and regulation competition; *Controls* are control variables; α is a constant term; β is the parameter to be estimated; μ_i and γ_t are the individual fixed effect at the firm level and the time fixed effect, respectively, which are used to reduce estimation bias caused by missing variables; ε_{it} is the random interference term.

The model introduces an interaction term between government competition and performance pressure to test further the role of performance pressure in the multi-dimensional competition of local governments and corporate green innovation, as shown below.

$$GI_{it} = \alpha + \beta_1 Comp_{it} + \beta_2 Pres_{it} + \beta_3 Comp_{it} * Pres_{it} + \beta_n Controls_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

Where, $Comp_{it} * Pres_{it}$ is the interaction term. The definitions of other variables are the same as provided above.

4. Empirical analysis

4.1. Descriptive statistics

The descriptive statistical results of core variables are shown in Table 1. It can be seen that the maximum value of growth rate competition is 26.509, and the minimum value is -5.337. It means significant differences in economic competition among different regions, with imbalanced development characteristics. The geographical distribution of listed companies is relatively wide, and resource endowments vary in different regions, resulting in an imbalanced trend in growth rate competition. Generally speaking, the eastern region has a well-developed industrial structure and has quickly become a new

engine of economic growth. Meanwhile, the central region, especially the western region, attaches more importance to economic goals, which hold greater weight in tournament competition.

The maximum and minimum values of fiscal competition are 6.745 and 1.074, respectively, and that of the investment attraction competition are 16.932 and 7.990. So, different local governments have differences in fiscal revenue and expenditure and the degree of investment competition. Fiscal competition reshapes the pattern of resource allocation, including capital, labor, and land, and then affects corporate green innovation. In recent years, more and more resources have been concentrated in the east, especially in coastal areas, under the influence of fiscal competition. It provides a means for the incentive mechanism of the Chinese-style decentralized governance model. The mean value of the investment attraction competition reaches 15.550, which reflects the weak ability to attract FDI in some regions and is far below the national average.

The maximum value of regulation competition is 0.728, and the minimum value is 0.017, indicating that the degree of regulation competition in local governments is weak. There is also the situation of mutual catch-up, with a standard deviation of 0.184. To compete for more economic resources and political interests, local governments may face “race-to-bottom” competition in environmental regulation. With the continuous improvement of the political evaluation system, the competition mode has gradually shifted to “race-to-top.” The environmental regulation tools and implementation efforts vary in different regions.

The maximum value of green innovation is 915, with a standard deviation of 24.582. This indicates great differences between different enterprises, which is consistent with China’s current imbalanced development characteristics of green innovation (J. M. Liu et al., 2024).

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev	Min	Max
<i>Comp</i> ₁	17388	10.063	4.968	−5.337	26.509
<i>Comp</i> ₂	17388	1.786	0.743	1.074	6.745
<i>Comp</i> ₃	17388	15.550	1.228	7.990	16.932
<i>Comp</i> ₄	17388	0.345	0.184	0.017	0.728
<i>GI</i>	17388	3.869	24.582	0.000	915.000
<i>Size</i>	17388	22.444	1.410	18.266	28.636
<i>Debt</i>	17388	0.479	0.203	0.007	0.994
<i>Cash</i>	17388	0.048	0.080	−0.805	0.920
<i>Cap</i>	17388	13.633	1.185	5.528	20.499
<i>Grow</i>	17388	0.019	0.757	−0.484	92.909
<i>Age</i>	17388	2.884	0.359	0.793	3.714
<i>Labor</i>	17388	7.867	1.386	2.197	13.223
<i>Prop</i>	17388	0.548	0.498	0.000	1.000
<i>Dual</i>	17388	0.196	0.397	0.000	1.000
<i>Stru</i>	17388	42.959	9.325	15.800	59.000
<i>Dens</i>	17388	6.172	1.108	2.043	8.281
<i>Open</i>	17388	0.495	0.440	0.005	3.654
<i>Fin</i>	17388	0.750	0.454	0.103	9.604

This table shows summary statistics of the variables employed in this study. *Comp*₁ ~ *Comp*₄ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *GI* is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

4.2. Basic regression analysis

Before regression analysis, the Hausman test is first conducted to determine whether random effect or fixed effect is more appropriate. If the Hausman statistic is negative or the P-value is insignificant, the null hypothesis is accepted, and the random effect should be selected. Otherwise, the fixed effect. The result shows that the statistic is positive, with a corresponding P-value of 0.000, showing that the fixed effect model should be chosen. So, growth competition, fiscal competition, investment attraction competition, and regulation competition are successively taken as core explanatory variables that are substituted into the model for fixed effect regression. The results from Model (1) to Model (4) in Table 2.

Growth and fiscal competition inhibit green innovation, which is significant at 1%. China's local governments have extensive resource control and administrative decision-making power (C. Xu, 2011). Driven by the goal of maintaining economic growth and political promotion, they intervene in economic activities within their jurisdictions. More resources are invested in productive infrastructure construction projects with low risk and quick returns. The financial support and subsidies for innovation activities are relatively weak (Abhimop et al., 2017; Daron et al., 2018). It results in self-interested investment behavior, which pays excessive attention to production while neglecting the importance of innovation. It is ultimately reflected in distorted innovation incentives. From the perspective of fiscal decentralization, to achieve higher fiscal revenue, local governments tend to increase the tax burden on enterprises within their jurisdiction in the fiscal competition. It may have a crowding-out effect on the funds used for

Table 2. Local government competition and green innovation.

Variable	Model (1) G_t	Model (2) G_t	Model (3) G_t	Model (4) G_t
$Comp_1$	-0.028(0.020)			
$Comp_2$		-0.640**(0.317)		
$Comp_3$			0.243*(0.129)	
$Comp_4$				2.221*(1.203)
$Size$	0.782*** (0.157)	0.784*** (0.157)	0.781*** (0.157)	0.783*** (0.157)
$Debt$	-0.964** (0.415)	-0.972** (0.415)	-0.950** (0.415)	-0.977** (0.415)
$Cash$	-0.684 (0.688)	-0.697 (0.688)	-0.713 (0.688)	-0.692 (0.688)
Cap	0.453*** (0.125)	0.451*** (0.125)	0.455*** (0.125)	0.456*** (0.125)
$Grow$	-0.029 (0.033)	-0.029 (0.033)	-0.029 (0.033)	-0.030 (0.033)
Age	1.120 (0.686)	1.154* (0.686)	1.064 (0.686)	1.097 (0.686)
$Labor$	1.054*** (0.144)	1.054*** (0.144)	1.056*** (0.144)	1.059*** (0.144)
$Prop$	0.350 (0.295)	0.350 (0.295)	0.336 (0.295)	0.367 (0.295)
$Dual$	-0.130 (0.147)	-0.131 (0.147)	-0.132 (0.147)	-0.128 (0.147)
$Stru$	0.005 (0.021)	-0.008 (0.023)	-0.003 (0.022)	0.002 (0.021)
$Dens$	1.267 (1.310)	1.002 (1.313)	1.197 (1.309)	1.511 (1.321)
$Open$	-0.127 (0.235)	-0.200 (0.234)	-0.139 (0.234)	-0.211 (0.235)
Fin	-5.176*** (0.845)	-4.580*** (0.808)	-4.728*** (0.802)	-5.209*** (0.830)
Cons	-36.525*** (8.411)	-33.814*** (8.525)	-39.842*** (8.582)	-39.011*** (8.508)
N	17388	17388	17388	17388
R ²	0.127	0.129	0.127	0.121

Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $Comp_1 \sim Comp_4$ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; G_t is corporate green innovation; $Size$ is firm scale; $Debt$ is capital structure; $Cash$ is cash flow level; Cap is capital intensity; $Grow$ is enterprise growth rate; Age is enterprise maturity; $Labor$ is number of employees; $Prop$ is property right; $Dual$ is separation of two rights; $Stru$ is industrial structure; $Dens$ is population density; $Open$ is opening intensity; Fin is financial development level.

innovation activities. The mismatch of fiscal authority and tax competition will further intensify its negative effect on innovation.

The regression coefficients of investment attraction and regulatory competition are 0.243 and 2.221, respectively, significant at 10%. It shows that they have a positive effect on green innovation. The reasons are as follows.

On the one hand, local governments bring capital, technology, and advanced management experience to the competition for investment attraction. It also enhances the attraction to talents, providing rich innovation resources for green innovation activities. In addition to improving production scale and efficiency, the competition for investment attraction accelerates the cross-regional flow of other factors. It can better exert the technology spillover effect and promote green innovation. It promotes the yardstick competition in green innovation, shifting from “race-to-bottom” to “race-to-top.” The traditional ways of investment attraction competition relying on factor inflows are gradually broken away, effectively promoting corporate green innovation. With the gradual improvement of the fiscal decentralization system, the innovation incentive framework has further enhanced the innovation behavior preferences of local governments. It enables them to strengthen their attraction of high-tech enterprises and the inflow of foreign capital during investment attraction competition. The continuous optimization of the innovation foundation, business environment, and infrastructure provides essential support for the smooth implementation of innovation activities. Governments have stronger motivation to provide more support for green and innovative enterprises and those with a strong willingness for green transformation.

On the other hand, green innovation has positive externalities when compared with other production and operation behaviors. Its demand for capital is higher, which requires the policy support of governments, as well as mandatory constraints on their emission behaviors. Environmental regulation virtually increases compliance costs (Clarkson et al., 2004; Petroni et al., 2019), forcing management to incorporate it into the firm’s objective function. Under the external pressure of stakeholders and the internal incentives of enterprises, green innovation strategies are made to achieve green competitive advantages and compensatory benefits that exceed the cost of environmental regulation (Du et al., 2018; Q. Y. Li & Xiao, 2020). Regulation competition in local governments reduces pollution and energy consumption in traditional enterprises with low technological levels. It helps to optimize the production structure continuously and moves towards the mid- and high-end, positively affecting green innovation.

4.3. Influence mechanism of performance pressures

According to the above conclusion, the relationship between the growth competition of local governments and corporate green innovation is not significant. So, in the following test of the influence mechanism of performance pressures, we focus on fiscal, investment attraction, and regulation competitions. The results are shown in Table 3.

The fiscal competition and interaction item coefficients are -0.410 and -0.519 , respectively. The former is no longer significant, and the latter is significant at 1%, indicating that implementing the new performance appraisal reduces the negative impact of fiscal competition on green innovation. In the political system of China’s pyramidal hierarchical structure, government departments have high discretionary power (Jin et al., 2005;

C. Xu, 2011). They can conduct biased public resource allocation regarding government subsidies and preferential tax policies and even determine the selection and appointment of lower-level government officials. As the periodicity of green innovation is long, it is challenging to realize economic benefits in the short term. Engaging in green innovation may cause local government officials to fail to reach their performance targets during their term of office. That's where the short-sighted behavior in government competition comes in (Kong, 2020), especially when officials' positions are transferred frequently. Additionally, the governments often take temporary restrictions to create a brief "political blue sky" in politically sensitive periods. So, the incentive effect of fiscal competition on green innovation is insufficient or even harmful.

Under the pressure of traditional economic performance, local governments have strong investment motivation and prefer to increase fiscal expenditure. Fiscal funds are concentrated in areas that efficiently produce political achievements, such as infrastructure projects with short construction cycles and quick results (Guo, 2007). Green innovation projects with extended periods and high risks are always ignored. As the performance pressure gradually turns to green political achievement pressure, the characteristics and patterns of government competition behavior have changed. The one-vote veto system will be implemented once their environmental indicators fail the assessment, directly affecting the promotion of officials. So local governments are committed to optimizing the allocation efficiency of financial funds, which alleviates the inhibition effect of fiscal competition on green innovation.

Table 3. The influencing mechanism of performance pressures.

Variable	Model (1) <i>GI</i>	Model (2) <i>GI</i>	Model (3) <i>GI</i>
<i>Comp₂</i>	−0.410(0.324)		
<i>Pres</i>	2.456*** (0.658)	−3.261** (1.316)	1.173* (0.616)
<i>Comp₂*Pres</i>	−0.519*** (0.146)		
<i>Comp₃</i>		0.043(0.139)	
<i>Comp₃*Pres</i>		0.299*** (0.077)	
<i>Comp₄</i>			1.275(1.249)
<i>Comp₄*Pres</i>			1.324** (0.470)
<i>Size</i>	0.791*** (0.157)	0.788*** (0.157)	0.782*** (0.157)
<i>Debt</i>	−0.992** (0.415)	−0.978** (0.415)	−0.993** (0.415)
<i>Cash</i>	−0.710(0.688)	−0.739(0.688)	−0.738(0.688)
<i>Cap</i>	0.452*** (0.125)	0.454*** (0.125)	0.451*** (0.125)
<i>Grow</i>	−0.030(0.033)	−0.030(0.033)	−0.030(0.033)
<i>Age</i>	1.116(0.686)	1.032(0.686)	1.038(0.686)
<i>Labor</i>	1.038*** (0.144)	1.037*** (0.144)	1.055*** (0.144)
<i>Prop</i>	0.311(0.295)	0.294(0.295)	0.351(0.295)
<i>Dual</i>	−0.128(0.147)	−0.123(0.147)	−0.116(0.147)
<i>Stru</i>	−0.014(0.023)	−0.001(0.022)	0.005(0.022)
<i>Dens</i>	−0.778(1.405)	0.338(1.327)	1.753(1.323)
<i>Open</i>	−0.173(0.234)	−0.194(0.234)	−0.346(0.240)
<i>Fin</i>	−3.005*** (0.922)	−3.468*** (0.864)	−5.378*** (0.832)
<i>Cons</i>	−24.187*** (8.943)	−32.382*** (8.789)	−39.754*** (8.511)
<i>N</i>	17388	17388	17388
<i>R²</i>	0.133	0.151	0.114

Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Comp₁ ~ Comp₄* are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *GI* is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

The coefficients of interaction terms of investment attracting competition and regulation competition with green innovation are 0.299 and 1.324, respectively, which are significant at 1% and 5%. It shows that implementing the new performance appraisal enhances the positive effect of investment attraction competition and regulation competition. On the one hand, the competition for investment attraction promotes the expansion of the regional economic scale and brings advanced knowledge, technology, and management experience. It provides the resource basis for corporate green innovation activities, which is better for playing the technical and structural effects of investment attraction competition. Under the pressure of green political achievement, more innovative resources generated by the investment attraction competition flow to green and low-carbon fields. Enterprises' environmental governance and green innovation intensity significantly improve (Y. J. Chen et al., 2018; J. He, 2006). On the other hand, adjusting the performance appraisal mechanism makes local governments face strong constraints on environmental protection indicators. To avoid being held accountable for failing to fulfill the environmental constraint indicators, officials formulate stringent environmental supervision policies, laws, and regulations in government competition (Hottenrott & Rexhäuser, 2015). They adopt command-control or market-incentive environmental regulation tools to constrain corporate pollution behaviors. Their regulation competition has gradually changed from "race-to-bottom" to "race-to-top," thus promoting healthy competition among local governments. Affected by the pressure of green performance, the financial expenditure on protecting the ecological environment will also increase. It plays a vital role in the green production of enterprises as well as the transformation of industrial structures (Zhou et al., 2017). Therefore, the new performance pressure positively impacts the relationship between regulation competition and green innovation.

The fiscal decentralization system reform also enables local governments to no longer rely solely on central governments to obtain budget expenditures. Under the guidance of green development, they can implement various measures to introduce talents, funds, and technology, thereby supporting the innovative development of enterprises within their jurisdiction. Policy tools, such as market access, pollutant discharge taxes, and innovation funds, enable them to solve the bottleneck problems that restrict economic development through green innovation. And then raise the entry threshold for foreign investment. So, green performance evaluation aims to promote healthy competition among local governments and attract investment and environmental regulations. It further strengthens the promoting effect of investment attraction competition and regulation competition on green innovation. The robustness test results are shown in the [Appendix A](#).

4.4. Further analysis

Due to unbalanced development, the relationship between government competition and green innovation may have regional heterogeneity in China (Y. Liu et al., 2024). According to the classification standard proposed by the State Planning Commission of China, all samples are divided into the eastern, central, and western regions. The group test method is used for re-estimation, and the results are shown in [Table 4](#).

The impact of growth competition and fiscal competition on corporate green innovation in the eastern region is negative, and the former is significant at 5%. The impact of investment attraction and regulation competition on corporate green innovation is positive and significant at 5% and 1%. The reason may be that the developed eastern region is often competitive, with more forward-looking and standardized policies. Compared with the central and western regions, the economic competition among local governments is more intense. The negative impact of growth competition on green innovation is more significant. Additionally, in the local government competition, it no longer pursues economic growth unilaterally but considers green and sustainable development. The “race-to-top” competition in the environment, innovation, and foreign investment in the eastern region has led to the transfer of production factors to technology-intensive industries (Dijkstra & Mathew, 2011). It forms the reverse-force effect on green innovation, and the innovation incentive effect of investment attraction competition and regulation competition is more significant.

Fiscal competition in the central and western regions hurts corporate green innovation, while competition in investment attraction has a positive impact. The coefficients are -0.928 and 0.213 , respectively, which are significant at 1% and 10%. It shows that the impact of fiscal competition and investment attraction competition on green innovation in central and western regions has not changed significantly. The coefficient sign is consistent with that of the eastern region. Such regions are often at a competitive disadvantage, and the government competition aims to achieve economic catch-up and political promotion by undertaking low-end industries in developed regions. Constrained by the weak economic foundation, corporate green innovation activities mainly depend on local government financial support. The innovation foundation and supporting facilities are also imperfect, resulting in the distortions in structure and resource allocation caused by the fierce financial competition. It ultimately shows a significant inhibition effect on green innovation. Compared with the eastern regions, the positive effect of investment attraction competition on green innovation in the central and western regions is weakened. The main reasons may be that the quality of investment attraction competition in those areas could be better, and fiscal decentralization could be more balanced. The poor price advantage of factors, coupled with the low degree of opening intensity, leads to insufficient innovation incentive effects.

It is worth noting that the impact of growth competition on green innovation in the eastern region is negative, while it is positive in the central and western regions. The impact of regulation competition on green innovation in the eastern region is positive, while it is negative in the central and western regions. The coefficient symbol changes significantly. On the one hand, the economically underdeveloped regions are often at a competitive disadvantage. So officials aim to achieve economic catch-up and political promotion in local government competition. It will also accelerate the acceptance of low-end industries in eastern regions to improve scale efficiency. Due to the relatively weak economic foundation, growth competition has not yet shown a negative innovation effect. On the other hand, the impact of the regulation competition on green innovation in the central and western regions is not significant. It indicates that there is a “race-to-bottom” competition in environmental regulation. Green innovation activities may lead to free-riding behavior in other regions but are characterized by positive externality. The economy in the central and western regions is relatively backward, so government

Table 4. Regional heterogeneity tests.

Area	Variable	Model (1) <i>GI</i>	Model (2) <i>GI</i>	Model (3) <i>GI</i>	Model (4) <i>GI</i>
Eastern regions	<i>Comp</i> ₁	−0.107** (0.042)			
	<i>Comp</i> ₂		−0.668 (1.013)		
	<i>Comp</i> ₃			0.578** (0.266)	
	<i>Comp</i> ₄				9.226*** (2.180)
	<i>Size</i>	1.082*** (0.240)	1.093*** (0.240)	1.070*** (0.240)	1.103*** (0.239)
	<i>Debt</i>	−1.488*** (0.637)	−1.520*** (0.637)	−1.458*** (0.637)	−1.552*** (0.636)
	<i>Cash</i>	0.217 (1.030)	0.215 (1.031)	0.183 (1.030)	0.382 (1.030)
	<i>Cap</i>	0.490*** (0.188)	0.480*** (0.188)	0.493*** (0.188)	0.491*** (0.188)
	<i>Grow</i>	0.007 (0.055)	0.008 (0.055)	0.009 (0.055)	0.003 (0.055)
	<i>Age</i>	2.787*** (0.978)	2.852*** (0.980)	2.769*** (0.979)	2.902*** (0.978)
	<i>Labor</i>	0.911*** (0.215)	0.895*** (0.215)	0.916*** (0.215)	0.895*** (0.215)
	<i>Prop</i>	−0.027 (0.500)	−0.034 (0.500)	−0.055 (0.500)	−0.140 (0.499)
	<i>Dual</i>	0.078 (0.215)	0.075 (0.215)	0.065 (0.215)	0.090 (0.215)
	<i>Stru</i>	0.072 (0.044)	0.081* (0.044)	0.045 (0.047)	0.032 (0.045)
	<i>Dens</i>	−1.615 (2.181)	−2.185 (2.220)	−2.434 (2.192)	−1.577 (2.178)
	<i>Open</i>	−0.031 (0.430)	−0.063 (0.430)	−0.027 (0.430)	−0.362 (0.436)
	<i>Fin</i>	−10.209*** (1.618)	−9.064*** (1.613)	−7.648*** (11.749)	−10.181*** (1.590)
	<i>Cons</i>	−26.685* (14.746)	−24.315 (15.292)	−31.687** (14.906)	−30.404** (14.760)
	<i>N</i>	11220	11220	11220	11220
	<i>R</i> ²	0.120	0.103	0.100	0.066
Central and western regions	<i>Comp</i> ₁	0.008 (0.018)			
	<i>Comp</i> ₂		−0.928*** (0.260)		
	<i>Comp</i> ₃			0.213* (0.116)	
	<i>Comp</i> ₄				−1.001 (1.227)
	<i>Size</i>	0.517*** (0.172)	0.525*** (0.172)	0.526*** (0.172)	0.516*** (0.172)
	<i>Debt</i>	−0.302 (0.436)	−0.301 (0.436)	−0.290 (0.436)	−0.297 (0.436)
	<i>Cash</i>	−1.477* (0.756)	−1.428* (0.754)	−1.435* (0.755)	−1.457* (0.755)
	<i>Cap</i>	0.173 (0.137)	0.150 (0.137)	0.166 (0.137)	0.172 (0.137)
	<i>Grow</i>	−0.040 (0.030)	−0.041 (0.030)	−0.041 (0.030)	−0.040 (0.030)
	<i>Age</i>	−1.570 (1.016)	−1.574 (1.014)	−1.671* (1.017)	−1.489 (1.018)
	<i>Labor</i>	0.968*** (0.160)	0.956*** (0.160)	0.957*** (0.160)	0.964*** (0.160)
	<i>Prop</i>	0.426 (0.272)	0.447* (0.271)	0.410 (0.272)	0.417 (0.272)
	<i>Dual</i>	−0.360** (0.171)	−0.355** (0.171)	−0.354** (0.171)	−0.360** (0.171)
	<i>Stru</i>	−0.004 (0.020)	−0.021 (0.020)	−0.009 (0.020)	−0.005 (0.020)
	<i>Dens</i>	0.853 (2.086)	−1.145 (2.158)	0.901 (2.085)	1.049 (2.099)
	<i>Open</i>	0.082 (0.139)	0.041 (0.139)	0.103 (0.139)	0.089 (0.139)
	<i>Fin</i>	−0.290 (0.695)	−0.209 (0.681)	−0.543 (0.687)	−0.364 (0.680)
	<i>Cons</i>	−20.411* (10.930)	−6.401 (11.594)	−22.854** (11.011)	−21.032* (10.962)
	<i>N</i>	6168	6168	6168	6168
	<i>R</i> ²	0.092	0.054	0.094	0.089

Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Comp*₁ ~ *Comp*₄ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *GI* is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

departments tend to relax environmental regulations to compete for resources (L. X. Yang et al., 2023). The “race-to-bottom” competition in regulation competition leads to a negative impact on green innovation.

Additionally, environmental pollution has negative externalities, resulting in social costs much higher than the potential benefits that polluters may receive. It will significantly reduce the enthusiasm of various entities for green innovation if pollution

behaviors are not punished. Meanwhile, the central and western regions are developed by relying on traditional resource-based industries, which will have a squeezing effect on other economic activities (L. N. Ma et al., 2022). According to the study of X. Li et al. (2023), the central region, especially the western region, overly relies on its natural resource endowment advantages. This leads to low-end technology lock-in for enterprises in the jurisdiction. The low marketization further makes it difficult to achieve innovation spillover effects. Thus forming the resource curse (Stevens, 2006). Therefore, the innovation effect of regulation competition in those regions is negative.

5. Conclusions and implications

5.1. Conclusions

Based on the perspective of multi-dimensional competition of local governments, this paper examines the relationship between macro-government behavior and micro-enterprise innovation behavior. It also discusses the mechanism of influence of performance pressures. The main conclusions are as follows:

First, the impact of local governments' multi-dimensional competition on corporate green innovation is diverse. Growth and fiscal competition hurt green innovation, and the former is insignificant. Investment attraction and regulation competition have a significant positive effect on green innovation. Second, the performance pressure gradually changes from economic growth to environmental governance. It effectively reduces the negative innovation effect of fiscal competition and enhances the positive effect of investment attraction and regulation competition. So the government competition gradually shifted from "race-to-bottom" to "race-to-top". Third, the competition for investment attraction in the eastern, central, and western regions can significantly promote corporate green innovation. However, the impact of growth and fiscal competition on green innovation in the eastern region is not apparent. Fiscal competition has a significant harmful impact on green innovation in the central and western regions.

5.2. Implications

This paper puts forward the following policy recommendations based on the above research conclusions.

First, local governments should focus on yardstick competition oriented toward green innovation and environmental protection. More efforts should be taken to strengthen foreign investment quality and efficiency and improve regulation policies to avoid the "race-to-bottom" competition. Then, the regional collaborative innovation networks should be built to promote the cross-regional flow of innovation factors, thus exerting the positive spatial spillover effect of the eastern region. Second, the performance appraisal system of local governments should be continuously optimized, which brings hard constraints on local government behavior. It can effectively reduce the improper competition that excessively pursues economic growth. The diversified and high-quality performance assessment positively influences corporate green innovation. Third, government departments should formulate differentiated policies based on their resource endowments, maximizing utility. The financial and policy support for green innovation

should also be improved, especially in the central and western regions. It improves the allocation efficiency of government resources and innovation factors and reduces the negative effect caused by growth competition and fiscal competition. Additionally, to alleviate the opportunistic behavior of enterprises, government departments should construct a reasonable evaluation system according to the difficulty of innovation and its potential economic value. It improves the quality and market competitiveness of corporate green innovation.

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Appendix A

The following methods are used for the robustness tests.

(1) Shifting mean values

Considering that the data on government competition and green innovation fluctuates wildly yearly, this paper adopts the moving average method to make re-estimation. The results of the fixed effect model are shown in Table A1.

Table A1. Robustness test results (moving average).

Variable	Basic regression				Influencing mechanism		
	Model (1) <i>GI</i>	Model (2) <i>GI</i>	Model (3) <i>GI</i>	Model (4) <i>GI</i>	Model (5) <i>GI</i>	Model (6) <i>GI</i>	Model (7) <i>GI</i>
<i>Comp</i> ₁	−0.054** (0.023)						
<i>Comp</i> ₂		−0.992*** (0.314)			−0.948*** (0.314)		
<i>Comp</i> ₃			0.334** (0.129)			0.176 (0.132)	
<i>Comp</i> ₄				5.197*** (1.194)			4.404*** (1.200)
<i>Pres</i>					2.227*** (0.505)	−4.314*** (1.106)	0.760* (0.455)
<i>Comp</i> ₂ * <i>Pres</i>					−0.615*** (0.126)		
<i>Comp</i> ₃ * <i>Pres</i>						0.343*** (0.066)	
<i>Comp</i> ₄ * <i>Pres</i>							2.407*** (0.404)
<i>Size</i>	0.819*** (0.142)	0.818*** (0.142)	0.820*** (0.142)	0.821*** (0.142)	0.827*** (0.142)	0.832*** (0.142)	0.821*** (0.142)
<i>Debt</i>	−0.774** (0.393)	−0.799** (0.393)	−0.770** (0.393)	−0.800** (0.393)	−0.830** (0.393)	−0.814** (0.393)	−0.850** (0.392)
<i>Cash</i>	−1.571* (0.807)	−1.561* (0.806)	−1.601** (0.806)	−1.600** (0.806)	−1.548* (0.806)	−1.606** (0.805)	−1.687** (0.805)
<i>Cap</i>	0.398*** (0.112)	0.394*** (0.112)	0.396*** (0.112)	0.402*** (0.112)	0.397*** (0.112)	0.396*** (0.112)	0.387*** (0.112)
<i>Grow</i>	0.022 (0.043)	0.022 (0.043)	0.023 (0.043)	0.023 (0.043)	0.020 (0.043)	0.019 (0.043)	0.024 (0.043)
<i>Age</i>	1.306** (0.550)	1.389** (0.551)	1.226** (0.550)	1.173** (0.550)	1.356** (0.551)	1.188** (0.550)	1.030* (0.550)
<i>Labor</i>	0.927*** (0.128)	0.930*** (0.128)	0.935*** (0.128)	0.943*** (0.128)	0.912*** (0.127)	0.910*** (0.128)	0.930*** (0.127)
<i>Prop</i>	0.283 (0.273)	0.299 (0.273)	0.261 (0.273)	0.250 (0.273)	0.249 (0.273)	0.196 (0.273)	0.318 (0.273)
<i>Dual</i>	−0.466*** (0.154)	−0.468*** (0.154)	−0.467*** (0.154)	−0.465*** (0.154)	−0.454*** (0.154)	−0.441*** (0.154)	−0.417*** (0.154)
<i>Stru</i>	0.002 (0.018)	−0.018 (0.020)	−0.009*** (0.019)	0.003 (0.018)	−0.024 (0.020)	−0.006 (0.019)	0.017 (0.018)
<i>Dens</i>	1.834 (1.210)	1.943 (1.209)	1.609 (1.201)	2.139* (1.209)	−0.546 (1.312)	0.537 (1.217)	3.271*** (1.222)
<i>Open</i>	−0.651* (0.347)	−0.853** (0.347)	−0.655* (0.346)	−0.908*** (0.347)	−0.812** (0.347)	−0.784** (0.347)	−1.603*** (0.366)
<i>Fin</i>	−6.377*** (0.856)	−5.469*** (0.790)	−5.453*** (0.791)	−6.967*** (0.848)	−3.435*** (0.894)	−3.536*** (0.872)	7.215*** (0.848)
<i>Cons</i>	−38.014*** (4.226)	−37.092*** (7.930)	−42.169*** (8.182)	−41.827*** (8.006)	−23.128*** (4.639)	−34.577*** (4.756)	−47.827*** (8.060)
<i>N</i>	17388	17388	17388	17388	17388	17388	17388
<i>R</i> ²	0.092	0.081	0.096	0.083	0.122	0.125	0.063

Note: Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Comp*₁ ~ *Comp*₄ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *GI* is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

Table A2. Robustness test results (changing time series).

Variable	Basic regression				Influencing mechanism		
	Model (1) G_{t+1}	Model (2) G_{t+1}	Model (3) G_{t+1}	Model (4) G_{t+1}	Model (5) G_{t+1}	Model (6) G_{t+1}	Model (7) G_{t+1}
<i>Comp</i> ₁	0.003 (0.022)						
<i>Comp</i> ₂		−0.767** (0.344)			−0.316 (0.366)		
<i>Comp</i> ₃			0.295** (0.140)			0.053 (0.152)	
<i>Comp</i> ₄				2.170* (1.269)			1.047 (1.347)
<i>Pres</i>					2.581*** (0.673)	−3.700*** (1.366)	0.966 (0.620)
<i>Comp</i> ₂ * <i>Pres</i>					−0.551*** (0.153)		
<i>Comp</i> ₃ * <i>Pres</i>						0.319*** (0.081)	
<i>Comp</i> ₄ * <i>Pres</i>							1.284** (0.517)
<i>Size</i>	0.777*** (0.166)	0.776*** (0.166)	0.775*** (0.166)	0.780*** (0.166)	0.789*** (0.166)	0.788*** (0.166)	0.779*** (0.166)
<i>Debt</i>	−0.928** (0.441)	−0.925** (0.441)	−0.900** (0.441)	−0.938** (0.441)	−0.962** (0.441)	−0.941** (0.441)	−0.956** (0.441)
<i>Cash</i>	−0.394 (0.711)	−0.360 (0.711)	−0.380 (0.711)	−0.384 (0.711)	−0.376 (0.710)	−0.396 (0.710)	−0.396 (0.710)
<i>Cap</i>	0.400*** (0.131)	0.398*** (0.131)	0.401*** (0.131)	0.401*** (0.131)	0.402*** (0.131)	0.403*** (0.131)	0.397*** (0.131)
<i>Grow</i>	−0.000 (0.034)	−0.001 (0.034)	0.000 (0.034)	−0.001 (0.034)	0.000* (0.034)	0.000 (0.034)	−0.000 (0.034)
<i>Age</i>	0.798 (0.746)	0.798 (0.746)	0.745 (0.746)	0.785 (0.746)	0.737 (0.745)	0.706 (0.746)	0.717 (0.746)
<i>Labor</i>	0.914*** (0.150)	0.915*** (0.150)	0.917*** (0.150)	0.918*** (0.150)	0.898*** (0.150)	0.898*** (0.150)	0.915*** (0.150)
<i>Prop</i>	0.634** (0.320)	0.637** (0.320)	0.624* (0.320)	0.655** (0.320)	0.593* (0.320)	0.576* (0.320)	0.642** (0.320)
<i>Dual</i>	−0.095 (0.155)	−0.100 (0.155)	−0.095 (0.155)	−0.094 (0.155)	−0.095 (0.155)	−0.084 (0.155)	−0.081 (0.155)
<i>Stru</i>	−0.032 (0.023)	−0.046** (0.023)	−0.048** (0.023)	−0.034 (0.022)	−0.042* (0.023)	−0.042* (0.023)	−0.030 (0.023)
<i>Dens</i>	0.184 (1.727)	0.181 (1.697)	0.070 (1.698)	0.786 (1.728)	−2.243 (1.824)	−0.877 (1.714)	1.602 (1.758)
<i>Open</i>	−0.217 (0.236)	−0.232 (0.234)	−0.176 (0.235)	−0.245 (0.235)	−0.261 (0.234)	−0.274 (0.236)	−0.375 (0.241)
<i>Fin</i>	−4.778*** (0.908)	−4.265*** (0.910)	−4.663*** (0.879)	−5.132*** (0.896)	−2.944*** (0.980)	−3.400*** (0.934)	−5.171*** (0.896)
<i>Cons</i>	−26.023** (10.961)	−24.259** (10.935)	−28.967*** (10.981)	−30.130*** (11.142)	−11.374 (11.498)	−20.648* (11.175)	−34.507*** (11.279)
N	15939	15939	15939	15939	15939	15939	15939
R ²	0.143	0.145	0.148	0.138	0.049	0.119	0.115

Note: Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Comp*₁ ~ *Comp*₄ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *G*_{*t*} is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

It shows that growth and fiscal competition hurt corporate green innovation, which is significant at 5% and 1%. Investment attraction and regulation competition positively impact corporate green innovation, which is significant at 5% and 1%, respectively. Although the level changes significantly, the signal is the same as the above. Additionally, the interaction terms of fiscal competition, investment attraction

Table A3. Robustness test results (considering endogeneity issues).

Variable	Model (1) GI_t	Model (2) GI_t	Model (3) GI_t	Model (4) GI_t
$Comp_1$	-2.695*** (0.433)			
$Comp_2$		-5.976*** (1.158)		
$Comp_3$			3.511*** (0.494)	
$Comp_4$				27.676*** (3.961)
<i>Size</i>	1.710*** (0.388)	2.091*** (0.330)	1.853*** (0.322)	2.013*** (0.351)
<i>Debt</i>	0.665 (1.136)	-0.890 (0.751)	-0.008 (0.802)	0.006 (0.897)
<i>Cash</i>	-10.323*** (2.377)	-3.372** (1.326)	-3.801*** (1.353)	-5.281*** (1.473)
<i>Cap</i>	-1.206*** (0.346)	-0.761*** (0.260)	-0.599** (0.257)	-0.796*** (0.281)
<i>Grow</i>	-0.034 (0.086)	-0.022 (0.045)	-0.024 (0.046)	0.002 (0.054)
<i>Age</i>	-8.950*** (1.720)	-0.886 (0.683)	-2.528*** (0.788)	-2.644*** (0.836)
<i>Labor</i>	0.159 (0.330)	0.534** (0.251)	0.633** (0.248)	0.325 (0.273)
<i>Prop</i>	1.185** (0.545)	0.061 (0.383)	0.321 (0.385)	0.528 (0.421)
<i>Dual</i>	-0.020 (0.526)	0.698 (0.437)	0.473 (0.442)	0.522 (0.445)
<i>Stru</i>	0.378*** (0.077)	-0.194*** (0.040)	-0.240*** (0.041)	-0.434*** (0.066)
<i>Dens</i>	-0.764*** (0.271)	-1.948*** (0.527)	-2.431*** (0.458)	0.306 (0.214)
<i>Open</i>	1.693** (0.751)	-4.435*** (0.879)	-0.773* (0.452)	0.332 (0.506)
<i>Fin</i>	-21.712*** (3.608)	-1.042 (1.053)	2.268** (1.110)	5.658*** (1.482)
Cons	35.598*** (12.583)	-1.132*** (9.020)	-58.982*** (5.770)	-23.710*** (5.580)
N	17388	17388	17388	17388
R ²	-1.22	0.188	0.182	0.078

Note: Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $Comp_1 \sim Comp_4$ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; GI is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level. It can be seen that one of the R^2 is negative because it is the fitting result of the structural model. The residual of the actual value of the endogenous variable is considered rather than the predicted value. So, R^2 in this model has no statistical significance, and there is no need to worry about the accuracy of the research results.

competition, regulation competition, and performance pressure are all significant at 1%, with coefficients of -0.615, 0.343, and 2.407. Therefore, the performance pressure weakens the negative innovation effect of financial competition and strengthens the positive effect of investment attraction and regulation competition. The results are consistent with the above.

(2) Changing time series

Since the formation of green innovation achievements needs some time (Tian & Wang, 2014), this paper examines the relationship between government competition, performance pressure, and corporate green innovation in the future. GI_{t+1} represents green innovation in the next year; the results are shown in Table A2.

It can be seen that the negative effect of growth competition and fiscal competition on green innovation in the next year has not changed, and the latter is significant at 5%. Meanwhile, investment attraction and regulation competition positively affect green innovation in the next year, and they are significant at 5% and 10%. The performance pressure weakens the inhibitory effect of financial competition on green innovation in the future period and strengthens the positive effect of investment attraction competition and regulation competition. The conclusions obtained are robust.

(3) Considering endogeneity issues

Many control variables at the enterprise and regional levels are introduced in the model, and multiple methods are employed for robustness testing. This paper uses the 2SLS method for re-

Table A4. Multi-segment time test.

Time	Variable	Model (1) <i>GI</i>	Model (2) <i>GI</i>	Model (3) <i>GI</i>	Model (4) <i>GI</i>
2009–2013	<i>Comp</i> ₁	−0.006(0.005)			
	<i>Comp</i> ₂		−0.347*** (0.107)		
	<i>Comp</i> ₃			0.279*** (0.059)	
	<i>Comp</i> ₄				−0.366(0.417)
	<i>Size</i>	0.899*** (0.139)	0.864*** (0.139)	0.855*** (0.138)	0.892*** (0.139)
	<i>Debt</i>	−0.671* (0.139)	−0.608(0.397)	−0.578(0.396)	−0.664* (0.394)
	<i>Cash</i>	−0.671(0.394)	−0.370(0.348)	−0.369(0.348)	−0.359(0.352)
	<i>Cap</i>	−0.431(0.348)	−0.068(0.096)	−0.061(0.095)	−0.073(0.096)
	<i>Grow</i>	−0.075(0.096)	−0.012(0.010)	−0.012(0.010)	−0.013(0.010)
	<i>Age</i>	0.053(0.010)	0.027(0.264)	−0.078(0.266)	0.037(0.267)
	<i>Labor</i>	0.194** (0.097)	0.205** (0.097)	0.210** (0.097)	0.197** (0.097)
	<i>Prop</i>	0.459** (0.222)	−0.408* (0.226)	−0.379* (0.225)	−0.472*** (0.223)
	<i>Dual</i>	0.142(0.140)	0.129(0.141)	0.123(0.140)	0.145(0.141)
	<i>Stru</i>	−0.034** (0.013)	−0.038*** (0.013)	−0.044*** (0.013)	−0.034** (0.013)
	<i>Dens</i>	0.000(0.000)	−0.000(0.000)	−0.000(0.000)	0.000(0.000)
	<i>Open</i>	0.049(0.055)	0.010(0.055)	0.026(0.055)	0.048(0.055)
	<i>Fin</i>	−0.003(0.007)	−0.005(0.007)	−0.003(0.007)	−0.003(0.008)
	<i>Cons</i>	−16.819*** (2.414)	−15.295*** (2.511)	−19.691*** (2.533)	−16.659*** (2.403)
2014–2020	<i>N</i>	7245	7245	7245	7245
	<i>R</i> ²	0.137	0.140	0.145	0.136
	<i>Comp</i> ₁	0.028(0.025)			
	<i>Comp</i> ₂		−1.210** (0.474)		
	<i>Comp</i> ₃			0.538** (0.208)	
	<i>Comp</i> ₄				3.550** (1.480)
	<i>Size</i>	1.739*** (0.447)	1.748*** (0.446)	1.716*** (0.448)	1.726*** (0.445)
	<i>Debt</i>	−2.060*** (0.756)	−2.078*** (0.749)	−1.996*** (0.757)	−2.042*** (0.749)
	<i>Cash</i>	−1.855(1.156)	−1.889(1.168)	−1.916(1.168)	−1.858(1.171)
	<i>Cap</i>	0.224(0.290)	0.215(0.288)	0.242(0.289)	0.219(0.290)
	<i>Grow</i>	−0.105** (0.045)	−0.106** (0.045)	−0.107** (0.045)	−0.106** (0.045)
	<i>Age</i>	1.127(1.204)	1.049(1.206)	0.721(1.200)	0.628(1.220)
	<i>Labor</i>	1.550*** (0.346)	1.537*** (0.344)	1.558*** (0.345)	1.540*** (0.346)
	<i>Prop</i>	−0.272(0.398)	−0.214(0.401)	−0.209(0.407)	−0.206(0.399)
	<i>Dual</i>	0.244(0.294)	0.237(0.294)	0.236(0.294)	0.247(0.293)
	<i>Stru</i>	−0.105*** (0.034)	−0.133*** (0.036)	−0.111*** (0.033)	−0.122*** (0.033)
	<i>Dens</i>	0.000(0.000)	−0.000(0.000)	−0.000(0.000)	0.000(0.000)
	<i>Open</i>	−0.287(1.005)	−1.035(1.127)	−0.602(1.054)	−0.319(1.013)
	<i>Fin</i>	−0.019(0.014)	−0.008(0.013)	−0.017(0.013)	−0.020(0.014)
	<i>Cons</i>	−47.784*** (8.862)	−44.155*** (8.943)	−54.227*** (8.791)	−46.203*** (8.775)
	<i>N</i>	10143	10143	10143	10143
	<i>R</i> ²	0.170	0.175	0.178	0.173

Note: Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Comp*₁ ~ *Comp*₄ are growth competition, fiscal competition, investment attraction competition, and regulation competition, respectively; *GI* is corporate green innovation; *Size* is firm scale; *Debt* is capital structure; *Cash* is cash flow level; *Cap* is capital intensity; *Grow* is enterprise growth rate; *Age* is enterprise maturity; *Labor* is number of employees; *Prop* is property right; *Dual* is separation of two rights; *Stru* is industrial structure; *Dens* is population density; *Open* is opening intensity; *Fin* is financial development level.

estimation to further address the potential endogeneity issues. Other enterprises' activities easily influence innovation decisions in the same industry and region (Kaustia & Rantala, 2015; Q. Y. Li & Xiao, 2020). So, there may be free-riding behavior. This paper selects the mean values of green innovation in the industry and region as instrumental variables. The results are shown in Table A3.

It can be found that the impact of growth competition on green innovation changes considerably after considering endogeneity issues. The coefficient is −2.695, which is significant at 1%. The impact of other competition dimensions on green innovation is consistent with the previous conclusions. The reason may be that the growth competition affects green innovation in two opposite ways. In the traditional competition environment centered on GDP growth, local officials prefer to invest resources in projects that can bring economic benefits, such as infrastructure construction. It has a resource-crowding effect on innovation activities. Implementing the new performance evaluation system

forces them to pay more attention to environmental governance and the green transformation of enterprises. The promoting effect on green innovation is formed in their jurisdiction. The instrumental variables selected in this paper may play a masking role in the innovation effect of one of the above channels. So, the impact of growth competition on green innovation is more significant. In the subsequent robustness tests, this paper will further consider the time-phased test method for re-estimation to enhance the robustness of the results.

(4) Multi-segment time test

This paper focuses on the impact of local governments' multi-dimensional competition on micro-enterprise innovation behavior. Generally speaking, green innovation activities generally do not affect the current macro policy-making, so there is no reverse causality. Meanwhile, the policy notice is selected as having a relative exogenous impact, which can reduce the interference of other factors in the results. To further improve the robustness of the above conclusions, this paper divides the period into 2009–2013 and 2014–2020. Then, it analyzes the innovation effects of government competition before and after the change in the performance appraisal system. The results are shown in [Table A4](#).

It can be seen that the impact of fiscal competition and investment attraction competition on green innovation has not changed significantly. However, the impact of growth competition and regulation competition on green innovation changed considerably. During 2009–2013, their coefficients were -0.006 and -0.366 , respectively, which are not significant. During 2014–2020, their coefficients turned positive, with coefficients of 0.028 and 3.550 , respectively, and the latter is significant at 5%. After implementing the new performance appraisal system, the emission quotas of sulfur dioxide and other major pollutants are directly linked with the political performance of local officials. They have to adjust environmental regulation policies and supervision behaviors to achieve the emission reduction tasks. Local governments consider both economic growth and environmental governance. So, the restriction of growth competition on green innovation is weakened, and the promotion of regulation competition on green innovation is increased.