

Government Environmental Attention, Environmental Regulation, and Quality-Oriented Development in China's Coastal Cities

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Abstract: Using panel data for 51 Chinese coastal cities from 2006 to 2020, this paper investigates how government environmental attention, the low-carbon city pilot program, and the Bay Chief System influence the quality-oriented development of coastal regions. Difference-in-differences and spatial econometric models are applied to identify policy mechanisms and spatial spillovers. The empirical results indicate that: (1) stronger government attention to environmental issues, together with the low-carbon city pilot and the Bay Chief System, significantly improves the development quality of coastal cities; (2) industrial upgrading and talent concentration are the main channels through which the two policies operate; (3) a cleaner energy structure and greater R&D input reinforce the effect of the low-carbon pilot, while R&D investment and green utility-model patents strengthen the effect of the Bay Chief System; (4) cities implementing both policies achieve a stronger policy effect than those covered by only one pilot, suggesting policy complementarity; and (5) coastal urban development quality shows significant positive spatial dependence. Government environmental attention and the low-carbon pilot generate beneficial spillovers to neighboring areas, whereas the Bay Chief System has not yet produced a statistically significant positive spillover. These findings offer empirical support for improving environmental governance in coastal regions and for strengthening inter-policy coordination and regional cooperation.

Keywords: government environmental attention; environmental regulation; coastal urban development quality; difference-in-differences; spatial spillover

1. Introduction

The report to the 20th National Congress of the Communist Party of China calls for efforts to "promote high-quality development, develop the marine economy, protect the marine ecological environment, and accelerate the building of a maritime power." Coastal regions have long been important engines of China's economic and social progress, yet rapid industrialization also exposes these areas to higher ecological vulnerability (Halpern, B, 2008). The quality-oriented development of coastal cities emerges when marine economic growth reaches a stage at which economic, social,

resource, and environmental systems must be coordinated. It requires the optimization of marine industrial structures, improvement of marine ecological conditions, stronger comprehensive marine capacity, and fairer distribution of marine public welfare. Advancing such development is therefore not only an adaptation to the new normal of economic growth, but also a practical route for building a modern economic system, sustaining stable growth, and responding to the evolving needs of Chinese society.

In this context, coastal cities are not ordinary regional units but compound spaces in which ports, industries, populations, ecosystems, and administrative responsibilities overlap. Their development performance depends not only on the growth of output, but also on whether growth can be supported by cleaner energy, efficient resource use, resilient public services, and a stable marine ecological environment. A city may record rapid economic expansion in the short run, yet still face declining development quality if industrial emissions, shoreline degradation, weak innovation capacity, or insufficient public welfare undermine long-term sustainability. For this reason, evaluating coastal development only through traditional economic indicators is insufficient. A more comprehensive perspective is required, one that places ecological constraints and governance capacity within the same analytical framework as economic and social progress. This paper therefore treats high-quality development as a multidimensional outcome and asks whether government attention and environmental regulation can jointly transform the development path of coastal cities.

Green development provides the basic pathway for improving the development quality of coastal cities (Geall, S, 2018). Prior studies have examined the green development level of coastal areas (Eikeset et al., 2018), the quality of marine economic development (Liu et al., 2017), marine industry measurement and evaluation (Y. Wang & N. Wang, 2019), marine ecological economy (Zheng et al., 2020), and marine ecological environment (S. Wang et al., 2021). Related research has also analyzed spatial-temporal patterns and dynamic evolution using methods such as super-efficiency SBM models with undesirable outputs, PCA-EM, kernel density estimation, and Markov chains. These approaches have been applied to assess urban green development efficiency (Wang, M.-X, 2018), green marine economic efficiency (Guo, J, 2022), the green development level of coastal zones (Bennett, N. J., 2019), the quality of development in coastal economic belts (Zhang, F, 2022), and the spatial evolution of coastal urban agglomerations (Xue & Wang, 2022; Fang, C, 2017). Other studies have explored the relationship between economic growth and marine pollution in coastal provinces and cities (Wang et al., 2020), the coupling coordination of coastal development systems (Zhang et al., 2021), marine economic growth patterns (Ren et al., 2018), and the performance of marine ecological civilization construction (Jiang et al., 2020). Overall, the literature

suggests that coastal urban development quality has improved, although substantial regional disparities and room for further improvement remain. A second stream of research focuses on the drivers of such development. Technological innovation is widely regarded as a key source of coastal high-quality development (Liu et al., 2021; Ren & Ji, 2021; Pan et al., 2019; Du et al., 2016; Jiang et al., 2021; Fagerberg, J, 2008) and an important factor supporting marine economic growth (Song & Ning, 2021; Teece, D. J., 2018). Artificial intelligence (Zhong, W, 2024), the digital economy (Deng, H, 2022), digital finance (Shen, H, 2024), environmental regulation (Yu & Wu, 2022; Gao & Wang, 2024), green finance (Lee, C., 2022; Zhu, 2020), and smart city construction (Hongli et al., 2021) have also been shown to promote sustainable transformation, green total factor productivity, and high-quality regional development (Shao et al., 2021). A third body of work emphasizes government preferences, environmental attention, environmental supervision, and policy instruments (Ye et al., 2021; Guo & Fang, 2021; Chen & Qian, 2020). As a leading actor in coastal green development, government can strengthen environmental supervision, reduce pollution, stimulate innovation, and guide industrial restructuring through policy tools. Accordingly, local decision-making preferences may shape the development quality of coastal regions (Ye et al., 2021). Scholars have documented the positive effects of innovative-city pilots, carbon trading, marine ecological civilization demonstration zones, marine ranching policies, and environmental regulation on green or high-quality development (Xu, Y, 2024; Cheng, J, 2019; Hu, Y, 2020; Calel, R, 2016; Ren et al., 2024; Qin et al., 2021; Nie et al., 2021; Ding et al., 2020).

Although existing studies provide rich evidence on the marine economy, green development, and ecological construction, they pay comparatively less attention to the policy and attention-based drivers of quality-oriented development in coastal cities. In particular, the interaction between government environmental attention and concrete environmental regulations has not been fully examined. To fill this gap, this paper uses data for 51 Chinese coastal cities during 2006-2020 and applies difference-in-differences and spatial econometric methods to estimate the effects and spillovers of government environmental attention (Enat), the low-carbon city pilot policy (Carb), and the Bay Chief System (Bay). The study contributes in three ways. First, it combines an internal governance perspective, namely government attention, with an external regulatory perspective, namely environmental policy. Second, it links attention allocation to specific policy instruments by jointly examining Enat, Carb, and Bay and their mechanisms. Third, it uses a spatial Durbin model to identify whether these factors influence only local cities or also neighboring coastal areas.

The distinction between government environmental attention and formal environmental regulation is also important. Environmental attention reflects how strongly local governments perceive and prioritize ecological issues in their policy agenda, while environmental regulation

represents concrete institutional arrangements and policy tools. Attention without effective instruments may remain at the level of political expression, whereas regulation without sufficient attention may suffer from weak implementation, limited coordination, or insufficient fiscal support. Examining the two together therefore helps explain not only whether green governance matters, but also how administrative priorities are converted into measurable development outcomes. In addition, coastal environmental problems often cross city boundaries through industrial linkages, population mobility, river-sea interactions, and the diffusion of technology and policy experience. A spatial perspective is thus necessary to avoid treating each city as an isolated unit. By incorporating spatial spillover analysis, this study can distinguish between local policy effects and effects transmitted to neighboring coastal cities.

2. Theoretical analysis and research hypotheses

2.1 Government environmental attention and quality-oriented coastal development

Green development is a central orientation of regional quality improvement. Since ecological protection has been incorporated into government performance evaluation, local authorities have increasingly sought to coordinate economic growth with environmental protection. Government environmental attention refers to the priority that local governments assign to environmental governance, energy conservation, and emission reduction; it is also a precondition for carrying out environmental protection work (Wang & Li, 2017). According to attention theory, the allocation of organizational attention affects the direction, frequency, and results of decision-making, and policy choices change when attention shifts (Cyert & March, 2003). In this study, local government environmental attention is understood as the sustained allocation of administrative attention and governance resources to ecological issues within the broader development-protection agenda. It connects policy intention with green development practice. Governance theory further suggests that local governments are core providers of regional public affairs, and their governance concepts and implementation capacity directly affect development quality. For coastal cities, the marine environment is fluid and interconnected across administrative boundaries. Environmental governance therefore requires local governments to coordinate departments such as environmental protection, industry and information technology, marine affairs, and development and reform, while also cooperating with neighboring cities, enterprises, and research institutions. Higher environmental attention can help build such collaborative governance mechanisms. In practice, coastal local governments that attach greater importance to environmental issues are more likely to improve environmental laws and regulations, strengthen pollution constraints, protect ecosystems, and encourage efficient resource use. They may also increase fiscal support and tax incentives for environmental projects, promote clean technologies and renewable energy, guide green and circular

137 industrial transformation, and improve public environmental awareness through publicity and
138 education. These actions improve ecological quality and support environmental protection, thereby
139 contributing to the quality-oriented development of coastal cities. Therefore, the following
140 hypothesis is proposed:

141 From a mechanism perspective, the influence of government environmental attention can be
142 understood as an agenda-setting and resource-allocation process. When environmental issues
143 receive more attention in government work reports, they are more likely to enter annual planning,
144 budget allocation, project approval, supervision, and performance evaluation. This may increase the
145 frequency of environmental inspections, improve the continuity of pollution-control projects, and
146 strengthen coordination among departments that previously operated in a fragmented manner.
147 Higher attention can also send a policy signal to enterprises and residents, encouraging firms to
148 adjust investment expectations and encouraging the public to participate in environmental
149 governance. These channels are particularly relevant in coastal cities, where environmental risks are
150 closely related to industrial layout, port logistics, marine resource use, and cross-boundary water
151 pollution.

152 **Hypothesis 1.** Greater local government environmental attention promotes the quality-oriented
153 development of coastal cities.

154 2.2 Coastal low-carbon city pilots and quality-oriented coastal development

155 Coastal cities are among China's most economically active areas, but they also face strong
156 ecological pressure. Energy conservation and low-carbon transformation are therefore essential for
157 improving coastal development quality (Zhou, P., 2010). The low-carbon city pilot policy aims to
158 reduce carbon emissions, explore low-carbon economic models, and establish a sustainable green
159 development system. The first group of low-carbon pilot provinces and cities was announced in
160 2010 and included four coastal cities: Tianjin, Hangzhou, Shenzhen, and Xiamen. Two additional
161 rounds followed in 2012 and 2017, after which 16 coastal cities were covered by the policy. As a
162 command-based environmental regulation, Carb combines incentives with constraints to reduce
163 total carbon emissions and carbon intensity and to encourage greener production patterns. Through
164 this mechanism, the policy seeks to align economic growth with ecological protection. From the
165 perspective of factor mobility, environmental regulation redirects production factors away from
166 high-pollution sectors and toward low-carbon, environmentally friendly industries that are better
167 suited to new markets and returns. Environmental regulation theory also suggests that stricter
168 regulation encourages enterprises to adopt cleaner energy and adjust their energy consumption
169 structure, thereby reducing energy intensity. Accordingly, Carb can support the transformation of
170 economic and industrial structures in pilot cities, foster emerging industries such as clean energy

and energy-saving environmental protection, cultivate low-carbon awareness and behavior, and promote ecological restoration and green development. On this basis, the following hypothesis is proposed:

The effect of the low-carbon pilot is not limited to direct emission reduction. In practice, the policy may reshape the behavior of firms and local governments through both constraint and incentive mechanisms. On the constraint side, carbon intensity targets and low-carbon assessment requirements raise the cost of maintaining outdated production modes and encourage enterprises to improve energy efficiency. On the incentive side, pilot cities often obtain stronger support for low-carbon projects, green infrastructure, clean-energy applications, and technological experimentation. These institutional conditions can stimulate investment in energy conservation, environmental protection, and emerging green industries. The policy may also generate a learning effect: once low-carbon practices are embedded in local planning, transportation, construction, and industrial policies, they gradually influence the broader urban development model. Therefore, Carb is expected to improve development quality by combining environmental pressure with innovation-oriented transformation.

Hypothesis 2. The coastal low-carbon city pilot policy promotes the quality-oriented development of coastal cities.

2.3 The Bay Chief System and quality-oriented coastal development

The Bay Chief System represents a marine ecological governance arrangement based on land-sea coordination. Marine economic theory emphasizes that coastal cities should pursue sustainable use of marine resources, develop marine green industries by relying on ecosystem services, and protect the marine environment so as to realize harmony between humans and the sea. Pilot implementation of the Bay Chief System began in coastal areas in 2017. Zhejiang Province and four cities-Qinhuangdao, Qingdao, Lianyungang, and Haikou-were included in the first group. Under this system, bay chiefs are assigned at different levels according to marine functional zoning and are responsible for protecting and managing designated bay areas. The arrangement clarifies local responsibilities for marine ecological protection and uses a hierarchical structure to form a long-term governance mechanism. Collaborative governance theory holds that complex environmental problems require cooperation across departments, regions, and actors. Bay governance involves marine resource protection, pollution control, shoreline management, water environmental protection, and ecological restoration, and it requires participation from departments responsible for marine affairs, fisheries, environmental protection, water resources, electric power, and maritime administration. Implementing the Bay Chief System can therefore reduce fragmentation in marine environmental management, integrate resources, coordinate planning, avoid redundant construction

and resource waste, and improve the comprehensive governance of the marine ecological environment. Based on this reasoning, the following hypothesis is proposed:

The Bay Chief System differs from general urban environmental policy because its object of governance is a relatively integrated land-sea ecological space. Pollution entering a bay may originate from coastal industries, river basins, aquaculture, ports, vessels, tourism, or urban domestic sources, and these sources are often supervised by different departments. Without a clear responsibility chain, marine governance can easily face overlapping authority, unclear accountability, and delayed response. The bay-chief arrangement attempts to overcome these problems by defining responsible persons, management boundaries, and coordination procedures. It is therefore expected to improve high-quality development by reducing ecological risks, enhancing the efficiency of marine environmental management, and creating a more stable ecological foundation for marine industries, tourism, and coastal public welfare.

Hypothesis 3. Implementation of the Bay Chief System promotes the quality-oriented development of coastal cities.

The conceptual framework is presented in Fig. 1.

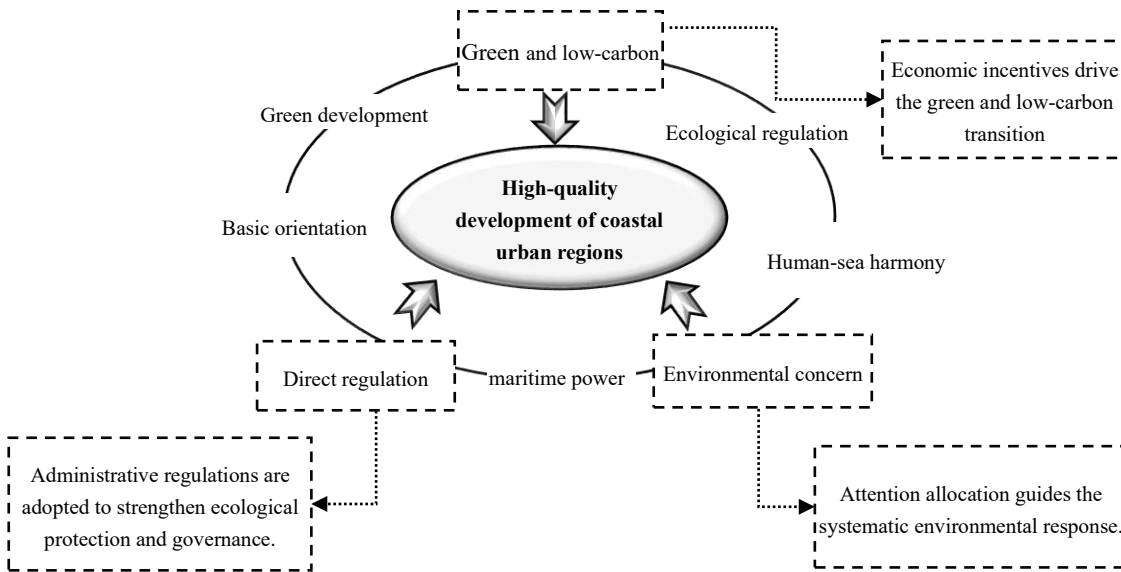


Fig. 1. Conceptual framework

3. Research design

3.1 Model construction

Using panel data for 51 coastal prefecture-level cities from 2006 to 2020, this study first estimates a two-way fixed-effects model to test the effect of Enat in a stepwise manner. The model is specified as follows:

The two-way fixed-effects specification is suitable for this setting because the sample covers multiple cities observed over a long period. City fixed effects absorb time-invariant differences such as location, historical industrial base, port conditions, and long-standing administrative

characteristics. Year fixed effects capture common shocks that affect all cities, including macroeconomic cycles, national policy adjustments, and changes in statistical standards. Under this framework, the estimated coefficient mainly reflects within-city changes over time after controlling for observed covariates and unobserved fixed heterogeneity. For the policy variables, the staggered DID design further uses differences in implementation timing to identify policy effects, which is consistent with the fact that both Carb and Bay were introduced in batches rather than simultaneously across all coastal cities.

$$Hiqd_{i,t} = c + \beta_1 Enat_{i,t} + \beta_2 Urban_{i,t} + \beta_3 Engel_{i,t} + \beta_4 Resid_{i,t} + \beta_5 Tert_{i,t} + \beta_6 Ste_{i,t} + \beta_7 Road_{i,t} + \beta_8 Popu_{i,t} + \beta_9 Temp_{i,t} + \beta_{10} Lnrain_{i,t} + \beta_{11} Light_{i,t} + year + city + \varepsilon_{i,t} \quad (1)$$

A staggered difference-in-differences model is then constructed to evaluate the effects of Carb and Bay (Beck et al., 2010; Xu et al., 2022; Huang & Xie, 2022; Dou & Zhang, 2022). This specification enables an empirical assessment of how the two policies affect the development quality of coastal cities. To reduce the influence of omitted variables and other unobserved factors that are constant over time, the analysis adopts a stepwise regression strategy and tests the effects of green policies under different model settings.

$$Hiqd_{i,t} = c + \beta_1 DID_{i,t} + \beta_2 Urban_{i,t} + \beta_3 Engel_{i,t} + \beta_4 Resid_{i,t} + \beta_5 Tert_{i,t} + \beta_6 Ste_{i,t} + \beta_7 Road_{i,t} + \beta_8 Popu_{i,t} + \beta_9 Temp_{i,t} + \beta_{10} Lnrain_{i,t} + \beta_{11} Light_{i,t} + year + city + \varepsilon_{i,t} \quad (2)$$

In the model, year denotes year fixed effects, while city denotes city-level individual fixed effects that capture time-invariant differences across cities and help control for omitted factors. The term ε is the random disturbance.

3.2 Variable definitions

3.2.1 Dependent variable

The dependent variable is the coastal-city high-quality development index (Hiqd). This paper builds an evaluation system from five subsystems-regional economy, resources, environment, science and technology, and society-as shown in Table 1. A comprehensive index is calculated for 51 cities from 2006 to 2020 by combining AHP weights with entropy weights.

The construction of Hiqd follows the idea that high-quality development should be evaluated as an integrated system rather than a single outcome. The economic subsystem reflects production capacity and external openness; the resource subsystem captures the supporting conditions for urban operation; the environmental subsystem measures both pollution pressure and environmental treatment; the science and technology subsystem represents innovation and knowledge capacity; and the social subsystem reflects public welfare and living conditions. Combining AHP and entropy weighting helps balance expert judgment and objective information contained in the data. In this way, the index reduces the risk that the empirical conclusions are driven by one narrow dimension of development.

Table 1 Indicator system and weights for quality-oriented development in coastal cities.

Subsystem	Specific Indicator	Subsystem	Specific Indicator
Economic	Index of Value-added of Secondary Industry (Previous	Resource	Per capita daily domestic water

Subsystem	Year = 100)	Subsystem	consumption (L)
	Index of Value-added of Tertiary Industry (Previous Year = 100)		Annual total electricity consumption (100 million kWh)
	Gross industrial output value of foreign-invested enterprises (100 million CNY)		Total urban gas supply (10,000 m ³)
	Actually utilized foreign capital of the current year (million USD)		Urban gas penetration rate (%)
	Total import and export volume of commodities (100 million USD)		Total highway mileage (1000 km)
	Foreign exchange revenue from international tourism (million USD)		Per capita park green area (m ²)
	Total wastewater discharge (100 million m ³)		Employment in scientific research, technical services, and geological prospecting (10,000 persons)
	Wastewater treatment rate (%)		Number of regular higher education institutions
Environmental Subsystem	Industrial soot emission (10,000 tons)	S&T Subsystem	Full-time faculty in regular higher education (person)
	Industrial sulfur dioxide (SO ₂) emission (10,000 tons)		Educational fiscal expenditure (100 million CNY)
	Harmless disposal rate of municipal solid waste (%)		Enrolled students in regular higher education (10,000 persons)
	Green coverage ratio of built-up districts (%)		Number of authorized patent grants
	Employees of health, social insurance, and social welfare sectors (10,000 persons)		Number of fixed internet subscribers (10,000 households)
Social Subsystem	Per capita household consumption expenditure (10,000 CNY)	Social Subsystem	Total beds in medical and health institutions (10,000 beds)
	Year-end registered urban unemployed population (10,000 persons)		Consumer Price Index (Previous Year = 100)

3.2.2 Independent variables

The core explanatory variables are defined as follows. First, Enat is measured by the share of environment-related terms in local government work reports. Following Chen Shiyi and Chen Dengke (Chen & Chen, 2018), the keyword list covers environmental protection, pollution, energy consumption, emission reduction, wastewater discharge, ecology, green, low-carbon, air, chemical oxygen demand, sulfur dioxide, carbon dioxide, PM10, and PM2.5. Second, Carb captures the policy effect of low-carbon city pilots. Group1 equals 1 for pilot cities and 0 otherwise, and Post1 equals 1 after the pilot begins and 0 before implementation. Their interaction term is defined as Carb; for a given coastal city, Carb equals 1 in the year of pilot designation and thereafter, and 0 otherwise. Third, Bay is defined in the same way. Group2 identifies cities implementing the Bay Chief System, Post2 indicates the post-implementation period, and their interaction term measures the policy effect of Bay. Because Carb and Bay were implemented in batches, the timing of the post-policy dummy varies across cities.

3.2.3 Control variables

To improve the reliability of the empirical estimates, the model includes a set of control variables used in prior research: Urban, measured by the urban population as a share of total year-end population; Engel, the Engel coefficient; Resid, the year-end savings balance of urban and rural

residents, measured in tens of billions of yuan; Tert, the share of tertiary-industry value added in GDP; Ste, science and technology expenditure, measured in billions of yuan; Road, per capita road area in square meters; Popu, the natural population growth rate; Temp, annual average temperature; Lnrain, annual average rainfall; and Light, the standardized mean value of nighttime lights.

These controls are included to reduce omitted-variable bias as much as possible. Urbanization and road conditions reflect urban expansion and infrastructure, while Engel's coefficient and household savings are related to residents' consumption capacity and welfare structure. The tertiary-industry share, science and technology expenditure, and nighttime lights capture economic structure, innovation support, and actual economic activity. Population growth and climate variables are included because demographic and natural conditions may also affect resource use, ecological pressure, and public-service demand. By controlling for these factors, the regressions focus more directly on the marginal contribution of environmental attention and the two policy interventions. The descriptive statistics of all main variables used in this study are presented in Table 2.

3.3 Data sources

The sample consists of 51 coastal prefecture-level cities in nine provinces. These cities are distributed across the Northern Marine Economic Circle (Liaoning, Hebei, and Shandong), the Eastern Marine Economic Circle (Jiangsu and Zhejiang), and the Southern Marine Economic Circle (Fujian, Guangdong, Guangxi, and Hainan). Shanghai and Tianjin, the two municipalities directly under the central government, are excluded because their inclusion may introduce extreme values and distort the estimates. The study period is 2006-2020, producing 765 city-year observations. Data are drawn from the China Statistical Yearbook, the statistical yearbooks of the nine provinces, the China City Statistical Yearbook, the China Regional Statistical Yearbook, the China Science and Technology Statistical Yearbook, and the China Environmental Statistical Yearbook. Additional data are obtained from the EPS Data Platform, including the China Regional Economic Database, China City Database, China Urban-Rural Construction Database, China Marine Database, and China Environmental Database, as well as the prefecture-level city database of the China Regional Research Data Support Platform.

Table 2 Descriptive statistics for the main variables.

Variable	Mean	Median	Sd	Min	Max
Hiqd	13.79	11.17	8.656	2.973	61.81
Enat	0.516	0.49	0.188	0.099	1.27
Carb	0.133	0	0.340	0	1
Bay	0.103	0	0.305	0	1
Urban	59.44	58.55	15.43	23.75	100
Engel	35.57	35.20	6.482	1.200	60.20
Resid	15.63	7.354	25.13	0.179	192.4
Tert	46.54	45.91	10.50	15.54	80.49

Ste	15.04	4.004	42.68	0.007	555.0
Road	17.71	16.22	7.078	2.950	41.05
Popu	6.611	6	6.098	-16.64	40.78
Temp	18.25	18.70	4.894	8.400	28.32
lnLnrain	7.056	7.245	0.641	3.408	8.078
Light	0.219	0.170	0.202	0.007	0.980

4. Analysis of empirical results

4.1 Baseline regression results

Table 3 reports the baseline regressions linking the three explanatory variables to coastal-city development quality. Because policy implementation and policy effects usually require time, Carb and Bay are lagged by one period. Columns (1)-(3) include controls but no fixed effects, whereas columns (4)-(6) add both year and city fixed effects. The estimated coefficients of Enat, Carb, and Bay are all significantly positive, indicating that stronger environmental attention, low-carbon pilot implementation, and the Bay Chief System each contribute to higher development quality in coastal cities. Thus, the preliminary results support Hypotheses H1, H2, and H3.

The baseline results should be interpreted as evidence that environmental governance contributes to a broader development transition rather than as a simple administrative effect. A positive coefficient on Enat suggests that when local governments devote more attention to environmental issues, development quality improves after other factors are controlled. The positive policy coefficients further imply that institutionalized regulation can transform attention into more concrete outcomes. The fact that the results remain significant after adding both city and year fixed effects strengthens the argument that the findings are not merely driven by stable regional advantages or common time trends.

Table 3 Baseline regression results for coastal-city development quality.

	Hiqd					
	(1)	(2)	(3)	(4)	(5)	(6)
Enat	1.8938*** (4.3131)			0.6574* (1.9368)		
L.Carb		2.9071*** (3.4546)			2.2259*** (3.2127)	
L.Bay			1.1813*** (3.4544)			1.0987** (2.5898)
Cons.	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Region FE	N	N	N	Y	Y	Y
Year FE	N	N	N	Y	Y	Y
R ²	0.7861	0.7942	0.7711	0.8586	0.8582	0.8452

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively; t-statistics are shown in parentheses. The same notation is used below.

4.2 Robustness tests

4.2.1 Parallel trend test

The validity of the difference-in-differences design requires the treatment and control groups

to have followed comparable pre-policy trends in the absence of intervention (Dou Wei and Zhang Shumin, 2022). Event-study regressions are therefore used to test the parallel-trends assumption for the two policy variables, and the results are displayed in Fig. 2 and Fig. 3. For Carb, the first implementation year is taken as the reference point. Fourteen coastal cities that launched low-carbon pilot programs in 2010 form the treatment group, while the remaining 37 cities serve as controls. Before 2010, the two groups show similar development trends, satisfying the parallel-trends condition. For Bay, 29 coastal cities implemented the system from 2017, and cities that began implementation in 2020 are treated as part of the control group. This yields 26 treated cities and 25 control cities. The pre-2017 trends are likewise comparable, indicating that the DID design passes the parallel-trends test.

The robustness strategy is designed to address different threats to identification. The parallel-trends test examines whether the treatment and control groups displayed comparable trends before policy implementation, which is a necessary condition for DID estimation. Propensity score matching reduces observable differences between pilot and non-pilot cities and therefore alleviates selection bias. The placebo test evaluates whether the estimated effect could be reproduced by randomly assigning treatment status; coefficients concentrated around zero provide evidence against spurious policy effects. Replacing the dependent variable and winsorizing Enat further test whether the results depend on a particular measurement method or on extreme observations. Finally, lag tests recognize that policy attention and regulation may need time to affect industrial structure, innovation behavior, and environmental outcomes.

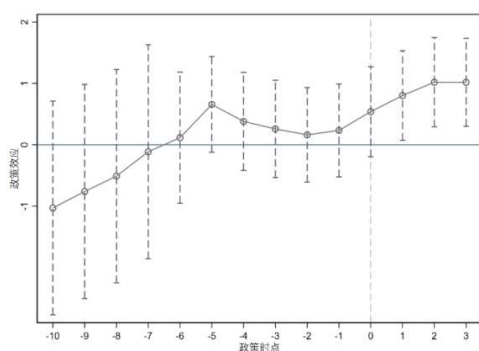


Fig. 2. Parallel-trends test for Carb

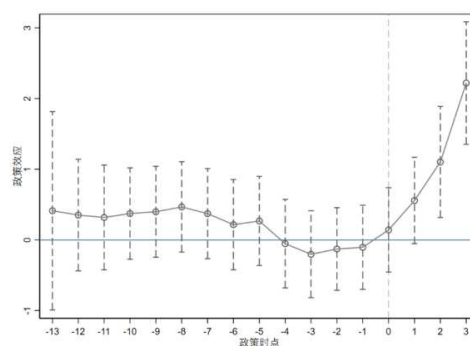


Fig. 3. Parallel-trends test for Bay

4.2.2 Propensity score matching test

Selection bias is an important source of potential endogeneity (Chetty et al., 2009). If unobserved characteristics affect whether a city enters the treatment or control group, the resulting non-random assignment may bias the estimates. Because the two policies studied here are not strict natural experiments, the analysis further uses a PSM-DID approach to reduce selection bias. Following Wooldridge (2010), all control variables are used as matching covariates, and nearest-

neighbor matching is performed at a 1:4 ratio between treated and control observations. Fig. 4 and Fig. 5 compare the density distributions of the two groups before and after matching. After matching, the distributions for both policies become more similar, suggesting that re-estimation with the matched sample can partially alleviate endogeneity caused by sample-selection differences.

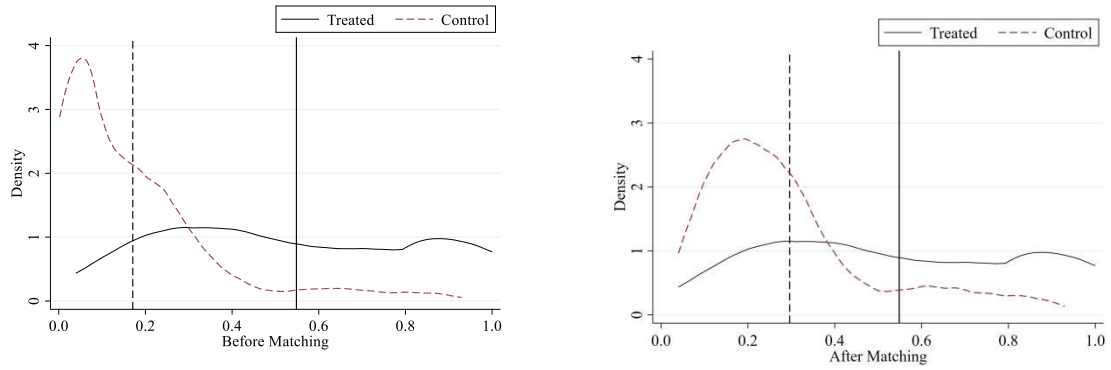


Fig. 4. Density distributions of the treatment and control groups before and after propensity score matching for Carb

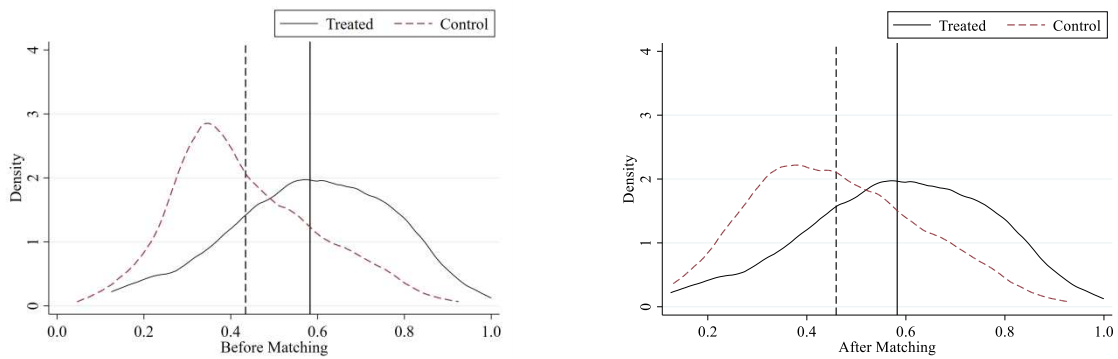


Fig. 5. Density distributions of the treatment and control groups before and after propensity score matching for Bay

Table 4 reports the estimates obtained after matching. Columns (1)-(4) show the results for pooled OLS, the fixed-effects model, observations with non-zero matching weights, and observations within common support, respectively. Carb and Bay continue to have significant positive effects on coastal-city development quality in the matched samples, and the magnitudes are broadly consistent with the pre-matching results. This suggests that selection bias is not driving the baseline findings and that the estimates are robust.

Table 4 DID regression results after propensity score matching.

	(1)	(2)	(3)	(4)
	Pooled OLS	Fixed-effects model	Non-empty weights	Satisfy the common support condition
L. Carb	3.3413*** (6.9081)	2.2259*** (3.2127)	0.7357** (2.1402)	0.7800* (1.7680)

L. Bay	0.4088 (0.7322)	1.0987** (2.5898)	0.8040* (1.9053)	0.6782* (1.7973)
Cons.	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Region FE	N	Y	Y	Y
Year FE	N	Y	Y	Y

4.2.3 Placebo test

To assess whether the estimated policy effects are affected by omitted variables, this study conducts placebo tests by randomly assigning treatment status 1,000 times and re-estimating the baseline model. The kernel density plots in Fig. 6 and Fig. 7 show that the coefficients from the random assignments are centered near zero and are clearly separated from the baseline coefficients of 2.2259 for Carb and 1.0987 for Bay. The placebo evidence therefore indicates that the positive effects of Carb and Bay are unlikely to be caused by omitted-variable interference, confirming the robustness of the baseline regressions.

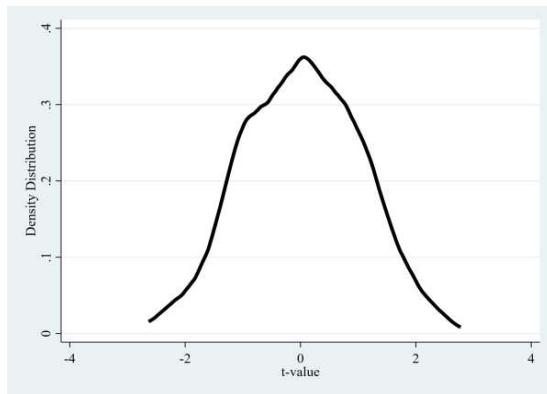


Fig. 6. Placebo test for Carb.

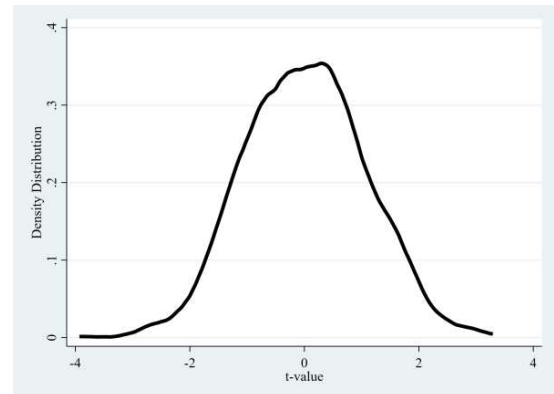


Fig. 7. Placebo test for Bay.

4.2.4 Alternative dependent variable and winsorization

A backpropagation (BP) neural network is used to recalculate the coastal-city high-quality development index, denoted as Hiqd2, and robustness tests are then conducted by replacing the dependent variable. Column (1) of Table 5 presents the regression of Enat on Hiqd2. The coefficient remains positive and significant at the 10% level, consistent with the baseline results. Columns (2) and (3) report the DID estimates for Carb and Bay using Hiqd2. The two policy variables are still positively associated with development quality at the 1% and 5% levels, respectively. These results support the robustness of the model specification.

Because Enat varies substantially across coastal cities, extreme values may influence the regression estimates. To address this concern, Enat is winsorized at the 1% level on both tails. As shown in column (4) of Table 5, the winsorized Enat coefficient remains positive and significant at the 10% level, again supporting the previous conclusion.

Table 5 Robustness checks using an alternative dependent variable and winsorization.

Hiqd

	(1)	(2)	(3)	(4)
Enat	0.6567*			0.6798*
	(1.9336)			(1.9606)
L.Carb		2.2254***		
		(3.2136)		
L. Bay			1.0992**	
			(2.5913)	
Cons.	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	765	714	714	765
R ²	0.8585	0.8582	0.8451	0.8586

4.2.5 Lag test

Government environmental attention may influence development outcomes with a time lag because attention must first be translated into policy measures before affecting development quality. The regression is therefore re-estimated after lagging Enat by one period. Column (1) of Table 6 shows that lagged Enat remains positively related to coastal-city development quality at the 5% significance level. Columns (2) and (3) further show that Carb and Bay remain significant after being lagged by two periods. These results provide additional evidence of robustness.

Table 6 Robustness test based on two-period lags.

	Hiqd		
	(1)	(2)	(3)
L. Enat	0.7840**		
	(2.1425)		
L2.Carb		2.2586***	
		(3.5636)	
L2. Bay			1.1585***
			(2.6881)
Cons.	Y	Y	Y
Controls	Y	Y	Y
Region FE	Y	Y	Y
Year FE	Y	Y	Y
N	714	663	663
R ²	0.8426	0.8436	0.8286

4.3 Analysis of transmission mechanisms

Industrial restructuring policies can guide resources toward sectors with higher value added, stronger efficiency, and lower energy consumption. They also reduce homogeneous competition and resource misallocation in traditional sectors, thereby supporting industrial upgrading and quality-oriented development (Li et al., 2022). This paper measures industrial structure advancement by constructing a weighted index across the three industries (Amiti, M, 2007), where a higher value indicates a higher-quality industrial structure. Human capital is another engine of long-run growth and industrial upgrading (Li & Cai, 2018). Talent agglomeration can enhance urban development through knowledge spillovers, technological innovation, management improvement, and

consumption upgrading (Sun, 2025; Ling et al., 2024). It is measured as the logarithm of employees in the information transmission, computer services and software industry plus employees in scientific research, technical services, and geological prospecting, divided by total urban employment (Wang et al., 2016). Columns (1)-(4) of Table 7 report the effects of Carb and Bay on industrial advancement and talent agglomeration after controlling for covariates and including region and year fixed effects. The results show that both policies promote industrial upgrading. Carb provides practical policy pathways and technological validation, while Bay strengthens regional coordination and ecological governance; together, they help shift industry from high energy use and high pollution toward higher value added and lower emissions. In addition, both policies accelerate talent concentration by using policy guidance, platform construction, project incentives, and regional coordination to attract talent. Through technological innovation, industrial upgrading, and governance improvement, these channels jointly support sustainable economic, environmental, and social development.

The mechanism results are consistent with the logic of green transformation. Industrial upgrading provides the production-side foundation for development quality because it shifts economic activity away from low-value and high-pollution sectors toward technology-intensive and service-oriented industries. Such restructuring can reduce resource dependence and improve the compatibility between growth and ecological protection. Talent agglomeration works from the knowledge and human-capital side. Skilled workers, researchers, and technical professionals are more likely to support clean technology adoption, environmental monitoring, digital governance, and efficient public management. When low-carbon pilots and bay governance improve expectations about green development, they can attract enterprises, projects, and professionals related to environmental services, marine science, and advanced manufacturing. Thus, industrial upgrading and talent concentration are not independent pathways; they may reinforce each other in the process of improving coastal development quality.

Table 7 Transmission mechanisms for coastal-city development quality.

	Advanced industrial structure		Talent agglomeration empowerment	
	(1)	(2)	(3)	(4)
L.Carb	0.1278*** (4.46)		0.0528*** (2.86)	
L. Bay		0.0800** (2.43)		0.0414** (2.16)
Cons.	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	714	714	663	663
R ²	0.8614	0.8591	0.8567	0.8592

4.4 Analysis of moderating effects

Table 8 examines how moderating factors shape the effect of Carb on coastal-city development quality. Clean energy structure is measured by the ratio of total social electricity consumption to total standard coal consumption. Following Andersson (2019), the low-carbon index of the energy consumption structure is used to measure energy low-carbonization, with provincial data matched to the city level. Green investment is measured by environmental pollution-control investment as a share of GDP, and R&D innovation input is measured by internal R&D expenditure as a share of GDP. Industrial-structure rationalization is measured by the Theil index following Gan et al. (2011), where lower values indicate a more balanced structure. The government-market relationship index from the Fan Gang index is also included as a moderator (Xie & Zhu, 2021). The regression results show that all interaction terms are significantly positive. Thus, a cleaner energy structure, stronger low-carbonization of energy consumption, larger environmental and R&D investment, and a more optimized government-market relationship all strengthen the contribution of Carb to coastal-city development quality.

These moderating effects indicate that the same environmental policy may produce different outcomes under different local conditions. A cleaner energy structure provides a material basis for low-carbon transformation, while greater R&D input improves the capacity to develop and adopt cleaner technologies. Green investment can accelerate the construction of pollution-control facilities and ecological restoration projects, and a better government-market relationship helps policy incentives operate through market mechanisms rather than relying only on administrative orders. For the Bay Chief System, the positive interaction with R&D investment and green patents suggests that marine ecological governance becomes more effective when it is supported by innovation capacity. Scientific monitoring, ecological restoration technology, and green equipment can all improve the precision and efficiency of bay management.

Table 8 Moderating-effect results.

	Clean energy structure	Low-carbon energy structure	Green investment	R&D investment	Government-market relationship
L.Carb*Me	0.0968*** (2.8077)	2.4313*** (2.7875)	1.4901** (2.0985)	0.7085*** (2.9634)	0.8480*** (2.8993)
L.Carb	1.7060*** (2.8098)	1.5594** (2.4189)	1.9867*** (3.1045)	2.4784*** (4.3532)	2.7163*** (5.0580)
Me	-0.0028 (-0.3391)	0.6099 (0.8014)	-0.3351* (-1.8974)	-0.0847** (-2.4957)	-0.3464** (-2.2999)
Cons.	8.2099*** (3.3770)	6.5106 (1.3851)	8.5977*** (3.3914)	8.8516*** (3.8324)	11.4774*** (4.4742)
Controls	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	714	714	714	714	714
R ²	0.8571	0.8591	0.8550	0.8592	0.8603

Table 9 analyzes the moderating effect of Bay. R&D innovation input is measured by internal R&D expenditure as a share of GDP, while green innovation is measured by the number of green

utility-model patent applications per 10,000 people in the current year. The interaction terms are significantly positive, indicating that higher R&D investment and more green utility-model patents enhance the effect of the Bay Chief System on coastal-city development quality.

Table 9 Moderating effects of the Bay Chief System on coastal-city development quality.

	R&D innovation investment	Green innovation effect
L. Bay*Me	0.7948** (2.5820)	0.4509** (2.1782)
L. Bay	2.0121*** (3.3750)	0.6120 (1.4242)
Me	-0.0981** (-2.3056)	0.2515*** (2.8582)
Cons.	8.9550*** (3.6650)	7.6628*** (3.0974)
Controls	Y	Y
Region FE	Y	Y
Year FE	Y	Y
N	714	714
R ²	0.8435	0.8456

4.5 Synergistic effects of dual-policy pilots

To compare the net policy effect of the dual-pilot arrangement with that of single-policy implementation, this study first removes all non-pilot observations. Cities implementing both Carb and Bay are treated as the treatment group, while cities covered by only one pilot form the control group. The coefficient Dual therefore captures the additional effect of joint implementation relative to a single pilot. Next, observations with only Bay and non-pilot observations are excluded; dual-pilot cities are compared with Carb-only cities, and the coefficient Dual-C measures the incremental effect of joint implementation over the Carb pilot alone. Finally, observations with only Carb and non-pilot observations are removed; dual-pilot cities are compared with Bay-only cities, and Dual-B measures the additional effect over the Bay Chief System alone. Table 10 reports the results. Column (1) shows that the coefficient of Dual is significantly positive at the 1% level. Column (2) indicates that Dual-C is also significantly positive at the 1% level, and column (3) shows that Dual-B is significantly positive at the 5% level. These findings imply that combined implementation of Carb and Bay produces a stronger improvement in coastal-city development quality than single-policy pilots, reflecting a synergistic effect greater than the sum of separate measures.

The advantage of the dual-pilot arrangement can be understood as policy complementarity. The low-carbon pilot focuses more on carbon reduction, industrial transformation, and the construction of low-carbon production and consumption systems. The Bay Chief System focuses more on marine ecological responsibility, land-sea coordination, and bay-area environmental management. When both policies are implemented in the same city, the former can improve the low-carbon orientation of economic activities, while the latter can strengthen the ecological foundation of coastal and marine spaces. Their combination therefore covers both the production transformation dimension

and the ecological governance dimension of high-quality development. This explains why the joint policy effect is stronger than the effect of a single pilot.

Table 10 Comparison between dual-pilot and single-pilot policy effects.

	Hiqd		
	(1)	(2)	(3)
Dual	0.9743*** (0.278)		
Dual-C		1.0525*** (0.310)	
Dual-B			1.1061*** (0.312)
Cons.	8.9862*** (2.215)	10.0738*** (2.570)	6.9038** (2.936)
Controls	Y	Y	Y
Region FE	Y	Y	Y
Year FE	Y	Y	Y
N	675	510	435
R ²	0.973	0.977	0.970

5. Further discussion: spatial spillover effects

5.1 Model specification

5.1.1 Spatial econometric model

Because the main variables may influence neighboring regions, this study further builds a spatial econometric model using the 2006-2020 panel data for 51 coastal cities. Compared with alternative spatial models, the spatial Durbin model can decompose spatial impacts into direct and indirect effects through the partial differential method (Lesage & Pace, 2011). The direct effect describes the impact on the local explained variable, whereas the indirect effect captures the average influence on other regions. The spatial Durbin model is specified as follows:

A spatial econometric perspective is especially relevant for coastal cities because their development systems are connected through ports, industrial chains, labor markets, and shared ecological spaces. Environmental improvement or industrial transformation in one city may affect nearby cities through demonstration effects, technology diffusion, factor mobility, and intergovernmental competition. Conversely, ignoring spatial dependence may lead to biased estimates because the outcome of one city is not fully independent of the outcomes of neighboring cities. The SDM framework directly incorporates these spatial interactions by including spatial lags of both the dependent variable and the explanatory variables, allowing the study to distinguish local effects from spillover effects.

$$\begin{aligned}
 Hiqd_{i,t} = & \theta_0 + \rho_0 W_{i,t} Hiqd_{i,t} + \alpha_1 Enat/Carb/Bay_{i,t} + \alpha_2 W_{i,t} Enat/Carb/Bay_{i,t} + \alpha_3 control_{i,t} \\
 & + \alpha_4 W_{i,t} control_{i,t} + \mu_{i,t} + \gamma_{i,t} + \varepsilon_{i,t}
 \end{aligned} \quad (3)$$

In Eq. (3), i denotes city and t denotes year. The spatial weight matrix is represented by W , and $Hiqd$ is the coastal-city development-quality index. $Enat$, $Carb$, and Bay denote government

environmental attention, the low-carbon city pilot policy, and the Bay Chief System, respectively. X denotes the control variables, and the corresponding spatial lag terms capture the influence of neighboring regions. City and year fixed effects are included, and ε is the random disturbance term.

5.1.2 Construction of the spatial weight matrix

A spatial econometric analysis requires an appropriate spatial weight matrix. This paper uses an inverse geographic distance matrix, where the geographic weight is defined as $W_{dij} = 1/d_{ij}$ and d_{ij} is the distance between two cities calculated from latitude and longitude coordinates. When $i = j$, the matrix element is set to 0. Under this specification, shorter distances imply larger spatial weights, while more distant city pairs receive smaller weights.

5.2 Spatial autocorrelation test

The panel Moran's I statistic for H_{iqt} is calculated under the inverse geographic distance matrix to test for spatial dependence. As shown in Table 11, the global Moran's I values from 2006 to 2020 are all positive, ranging from 0.057 to 0.092, and all pass the significance test. This indicates that the development quality of coastal cities is positively spatially correlated, providing a basis for subsequent spatial econometric estimation.

The positive Moran's I values imply that coastal cities with higher development quality tend to be located near cities that also have relatively high development quality, while cities with lower development quality tend to be clustered with similar neighbors. This pattern may reflect the geographic concentration of advanced industries, infrastructure networks, port-related agglomeration, and regional policy learning. It also suggests that coastal development should not be managed only through isolated city-level interventions. Regional coordination, cross-city environmental governance, and shared innovation platforms are likely to be important for improving overall development quality along the coast.

Table 11 Spatial correlation test for the coastal-city development-quality index.

年份	Moran's I	P-value	Z-value	Year	Moran's I	P-value	Z-value
2006	0.057	0.028	2.201	2007	0.073	0.008	2.659
2008	0.086	0.003	3.012	2009	0.068	0.012	2.523
2010	0.068	0.012	2.498	2011	0.070	0.010	2.582
2012	0.071	0.010	2.583	2013	0.078	0.006	2.776
2014	0.071	0.010	2.587	2015	0.092	0.001	3.207
2016	0.083	0.003	2.947	2017	0.082	0.004	2.910
2018	0.086	0.003	3.016	2019	0.079	0.004	2.854
2020	0.068	0.013	2.492				

5.3 Spatial econometric results and analysis

Several diagnostic tests are conducted to justify the use of the spatial Durbin model (Han et al., 2020). The LM-lag, robust LM-lag, LM-error, and robust LM-error tests are significant at the 1% level, implying that both SAR and SEM specifications are potentially applicable. The LR and Wald tests further reject the hypotheses that the SDM can be simplified into either SAR or SEM.

Accordingly, this study adopts a two-way fixed-effects spatial Durbin model.

Columns (1)-(3) of Table 12 present the spatial Durbin estimates based on the inverse geographic distance matrix for Enat, Carb, Bay, and Hiqd. The results indicate positive spatial autocorrelation in the coastal-city development-quality index; an improvement in one city can help raise the development quality of nearby coastal cities. The coefficients of the three explanatory variables are significantly positive at the 10%, 1%, and 5% levels, respectively, confirming that Enat, Carb, and Bay all promote coastal-city development quality and further supporting Hypotheses H1-H3. The spatial lag terms of Enat and Carb are also significantly positive, indicating that local environmental attention and low-carbon pilot implementation can generate positive effects in neighboring cities.

Point estimates from the spatial econometric model do not by themselves fully reveal spatial spillover effects. To identify the local and neighboring impacts more precisely, this paper follows Elhorst's approach (Li & Cai, 2018) and decomposes the spatial Durbin estimates into direct and indirect effects using the partial differential method. Columns (4)-(9) of Table 12 report the decomposition results. Enat has significantly positive direct and indirect effects, and Carb also shows significant direct and indirect effects. These findings mean that higher Enat and implementation of Carb not only improve the development quality of the city itself but also raise the development quality of surrounding cities. Ignoring spatial interactions would therefore underestimate their overall effects. Two explanations are possible. First, stronger government environmental attention reflects a greater policy focus on green development, and related measures can produce demonstration effects for neighboring areas. Likewise, low-carbon pilot implementation creates institutional pressure that encourages nearby cities to learn from advanced low-carbon practices and adopt competitive green strategies. Second, geographically close cities are better positioned to share knowledge, technology, and governance experience, which improves green development welfare in adjacent regions. By contrast, Bay has a significant direct effect but an insignificant indirect effect. This suggests that the Bay Chief System currently improves local development quality but has not yet generated significant spillovers to surrounding cities.

The difference between the spillover effects of Carb and Bay also deserves attention. Low-carbon policies are easier to diffuse across cities because they often involve transferable technologies, comparable assessment indicators, and visible industrial practices such as energy-saving projects and green transportation. Neighboring cities can imitate these practices or face competitive pressure to adopt similar strategies. By contrast, the Bay Chief System is more closely tied to specific bay boundaries, hydrological conditions, and local administrative responsibility chains. Its governance benefits may therefore be concentrated within the implementing city or bay

area in the short run. Strengthening cross-bay and cross-city coordination may be necessary before its spillover effect becomes more visible.

Table 12 Spatial Durbin results based on the inverse geographic distance matrix.

	Hiqd		Direct		Indirect	Direct		Indirect	Direct	Indirect
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Enat	0.627*			0.791**	9.015**					
	(1.70)			(2.02)	(2.26)					
W*Enat	5.000**									
	(2.41)									
L. Carb		2.649***				2.861***	12.940***			
		(10.66)				(10.30)	(3.82)			
W*L.Carb		7.007***								
		(4.30)								
L. Bay			0.793**					0.850***	2.953***	
			(2.54)					(2.74)	(3.58)	
W*L. Bay			1.532							
			(1.32)							
rho	0.404***	0.375***	0.374***	0.404***		0.375***		0.374***		
	(4.19)	(3.83)	(3.73)	(4.19)		(3.83)		(3.73)		
Cons.	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	
N	765	765	765	765	765	765	765	765	765	
R ²	0.633	0.710	0.629	0.633	0.633	0.710	0.710	0.629	0.629	

Table 13 reports the spatial Durbin estimates and effect decompositions based on the economic-geography matrix for Enat, Carb, Bay, and Hiqd. The conclusions are consistent with those obtained from Table 12.

Table 13 Spatial Durbin results based on the economic-geography matrix.

	Hiqd		Direct		Indirect	Direct		Indirect	Direct	Indirect
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Enat	0.915**			1.047***	2.496***					
	(2.41)			(2.73)	(2.65)					
W*Enat	1.484**									
	(2.18)									
L.Carb		0.731***				0.783***	1.713***			
		(3.32)				(3.57)	(4.74)			
W*L.Carb		1.367***								
		(3.93)								
L. Bay			0.509**					0.519**	0.363**	
			(1.99)					(1.98)	(2.08)	
W*L. Bay			0.322							
			(0.60)							
rho	0.311***	0.154***	0.016**	0.311***		0.154***		0.016**		
	(6.28)	(2.70)	(2.26)	(6.28)		(2.70)		(2.26)		
Cons.	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Region FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	
N	765	765	765	765	765	765	765	765	765	
R ²	0.728	0.706	0.811	0.728	0.728	0.706	0.706	0.811	0.811	

6. Conclusions and policy implications

Taking 51 Chinese coastal cities from 2006 to 2020 as the research sample, this study examines how environmental attention and two green development policies-Enat, Carb, and Bay-affect coastal-city development quality from the perspective of attention allocation and policy implementation. The main findings are as follows. First, stronger Enat and the implementation of Carb and Bay all significantly improve the quality-oriented development of coastal cities. Second, Carb and Bay operate mainly through industrial upgrading and talent agglomeration. Third, the effect of Carb becomes stronger when the energy mix is cleaner, energy consumption is more low-carbon, environmental pollution-control investment and R&D input increase, and the government-market relationship improves. The effect of Bay is enhanced by greater R&D investment and more green utility-model patents. Fourth, the joint implementation of Carb and Bay produces a stronger effect than single-policy pilots. Fifth, coastal-city development quality exhibits significant positive spatial autocorrelation. Enat and Carb generate positive spatial spillovers: they improve not only local development quality but also that of surrounding coastal cities. Bay, however, has not yet shown a significant effect on neighboring regions.

Based on these findings, coastal cities should build a promotion system that uses sustained government environmental attention as guidance, the coordinated implementation of Carb and Bay as the core, and industrial upgrading and talent concentration as key channels. Environmental governance and green low-carbon objectives should be integrated into local development plans and performance evaluations. Where conditions permit, priority should be given to joint implementation of Carb and Bay so that policy coordination can release an integrated effect greater than either policy alone. Policy execution should also focus on the two main channels identified above: green industrial transformation and high-end talent agglomeration. Resources should be directed toward clean energy, low-carbon technologies, and ecological industries, while systems for attracting and training talent should be strengthened. In addition, cities should continue to improve the energy consumption structure, increase environmental-pollution-control investment, and enhance government-market collaboration. Greater input into clean-energy transition and R&D innovation can further amplify policy effectiveness. Finally, the spatial spillover of Carb should be used to encourage experience sharing, technological cooperation, and market linkages among neighboring cities. Given the currently weak regional spillover of Bay, cross-administrative coordination mechanisms should be innovated, and cooperation in bay co-governance and ecological-product value realization should be strengthened.

Several additional policy implications follow from the empirical results. First, government environmental attention should be made stable and operational rather than campaign-style. Local

623 governments can establish regular mechanisms for identifying marine ecological risks, reporting
624 environmental progress, and linking environmental objectives with fiscal expenditure and official
625 assessment. Second, the implementation of low-carbon policies should be coordinated with
626 industrial, transportation, construction, and energy policies so that emission reduction is embedded
627 in the whole urban system. Third, the Bay Chief System should be connected with watershed
628 management, shoreline protection, port governance, and marine ecological restoration, because bay
629 pollution and bay protection are closely related to land-based activities. Fourth, regional cooperation
630 platforms among neighboring coastal cities should be strengthened. Joint monitoring, data sharing,
631 coordinated enforcement, and cross-city ecological compensation can help transform local policy
632 effects into regional improvements. Finally, cities should pay attention to the supporting role of
633 innovation and talent. Without sufficient technical capacity and professional personnel,
634 environmental regulation may remain at the level of compliance, whereas with strong innovation
635 support it can become a source of sustainable competitiveness.

636 This study also has limitations that point to future research. The measurement of government
637 environmental attention relies on the frequency of environmental terms in government work reports.
638 Although this method is widely used, it may not fully capture the quality of policy implementation
639 or the actual allocation of fiscal and administrative resources. Future studies could combine text
640 analysis with budget data, project data, environmental enforcement records, or firm-level responses
641 to provide a more detailed picture of the attention-policy-performance chain. In addition, this study
642 focuses on prefecture-level coastal cities during 2006-2020. As more recent data become available,
643 future research could examine whether the effects of low-carbon pilots and the Bay Chief System
644 change under newer carbon-neutrality targets and marine ecological policies. Micro-level evidence
645 from enterprises, ports, and bay-management units would also help clarify the behavioral
646 mechanisms behind the city-level findings.

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