

Environmental regulation and high-quality economic growth—Quasi-natural experimental evidence from China

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37 session of the Standing Committee of the National People's Congress passed the
38 amendment to the Environmental Protection Law, which has been described as the
39 "strictest environmental protection law in history" , and in 2018, the construction of
40 ecological civilization was written into China's constitution, and the major strategic
41 decision of "carbon peaking and carbon neutrality" was proposed in 2021. However,
42 due to the discrepancy between the objectives of the central government and local
43 governments, the central government attaches importance to high-quality economic
44 growth, while local governments are constrained by their economic interests with
45 companies, making the problems of 'legislation over enforcement' and 'softening' of
46 environmental policy implementation widespread in reality.

47 To reverse the plight of local environmental governance failures, environmental
48 protection interview and central environmental protection inspection have quietly
49 emerged. In May 2014, the Ministry of Environmental Protection issued the Interim
50 Measures to propose a system of interviews, which introduced the interview system,
51 which is a system for local governments to conduct admonishing interview, point out
52 relevant problems, and put forward rectification requirements for major government
53 officials by the law for failing to fulfill their environmental protection responsibilities
54 or not fulfilling their responsibilities in place. In September 2014, the Ministry of
55 Environmental Protection interviewed the mayor of Hengyang City about the serious
56 lag in the construction of emission reduction projects, officially kicking off the prelude
57 to the environmental protection interview.

58 Environmental protection interview was mandatory before the interview
59 (requiring the presence of the main person in charge of the local government or
60 enterprise), but it was not followed by mandatory measures to further punish the
61 interviewee, thus making the interview a soft binding force. Immediately afterward, in
62 January 2016, the central environmental protection inspection began with a pilot
63 inspection in Hebei province and expanded nationwide in four batches. The central
64 environmental protection inspection, in the name of the Party Central Committee and
65 the State Council, gave higher authority to environmental enforcement, emphasizing
66 the "party and government share responsibility" for environmental protection and the
67 "double responsibility of one post". According to the report of the Central
68 Environmental Protection Inspection, 2,115 companies were punished in the fourth
69 batch of inspections, with penalties amounting to 94.4924 million RMB; 122 cases were
70 opened for investigation, 146 people were detained, and 1,797 people were held
71 accountable, as the central environmental protection inspection took mandatory
72 measures to further punish the inspection' clients, thus making the environmental
73 protection inspection a hard binding force.

74 Environmental protection interview and central environmental inspection
75 transcend the logic of the section system's operation and are important tools for the
76 central government to urge localities to fulfil their environmental responsibilities and
77 implement environmental policies. So, can innovative approaches to enforcement
78 promote quality economic growth respectively? What exactly is the relationship
79 between the synergistic governance mechanisms of the soft binding force of
80 environmental protection interview and the hard binding force of environmental

81 protection inspection and high-quality economic growth? How do synergistic
82 governance models affect the quality of economic growth? In what ways are they
83 heterogeneous in terms of their impact on quality economic growth? To address these
84 questions, this paper attempts to assess the policy effects of both using an empirical
85 approach.

86 **Literature review**

87 Environmental regulation is a regulatory policy or measure for the production
88 activities of polluting companies formulated by the government to solve the problem
89 of the negative external environmental effects. Previous studies on environmental
90 regulation mainly focused on the following three aspects:

91 For one thing, some articles evaluated the impact of environmental regulation on
92 regional economic growth. The research on the impact of environmental regulation on
93 regional economic growth was mostly carried out around the level of urban innovation
94 or total factor productivity. Yin et al. (2015) showed that environmental regulation
95 improves the level of urban technological innovation and accelerates the arrival of the
96 inflection point of the environmental (Brunnermeier and Cohen 2003). Pu et al. (2021)
97 proved that the relationship between environmental regulation and economic growth in
98 the Yangtze River Delta region from 2002 to 2010 was inverted U-shaped, and verified
99 that technological innovation and resource consumption were the transmission
100 mechanisms of environmental regulation to promote economic growth. Cao et al.(2020)
101 argued that the relationship between environmental regulation and economic growth in
102 the Yangtze River Delta region from 2002 to 2010 is an inverted "U"-shaped
103 relationship, and verified that technological innovation and resource consumption are
104 the transmission mechanism for environmental regulation to promote economic growth.

105 For another thing, several studies have discussed the relationship between
106 environmental regulation and firm performance. Some scholars argued that, as
107 microeconomic agents, companies have negative externalities in their production
108 process, and that environmental regulations internalize the external costs caused by
109 their emissions and increase their compliance costs, thus negatively affecting their
110 performance (Gray 1987; Jorgenson and Wilcoxon 1990). Others in the mainstream,
111 such as Porter, hold the opposite view. The "Porter hypothesis" believes that strict and
112 reasonable environmental regulations can stimulate companies to innovate and obtain
113 compensation for product innovation, and this innovation compensation effect will
114 offset some or all of the compliance costs of companies, thus improving enterprise
115 performance (Linde 1995). Many scholars have used the Porter Hypothesis as a
116 theoretical basis to explore the relationship between environmental regulation and
117 economic growth. Labor productivity was used as a measure of the quality of economic
118 growth (Chen and Chen 2018), proving that the Chinese government's environmental
119 pollution control was effective in improving air quality and driving up the quality of
120 economic growth. Shi et al.(2018) argued the relationship between environmental
121 regulation and economic growth in a quasi-natural experiment using the construction
122 of civilized cities, and showed that the construction of civilized city pilots reduces
123 transaction costs in cities, significantly increases the total factor productivity and labor

124 productivity of companies, and promotes high-quality economic growth. In addition to
125 these two views, some scholars argued that environmental regulation has an uncertain
126 relationship with firm performance, and the impact of environmental regulation on firm
127 performance was insignificant when the increase in firm costs caused by environmental
128 regulation was a small proportion of the firm's operating costs(Tu et al. 2019;Wang and
129 Liu 2014;Huang et al.2015).

130 And thirdly, some studies focused on the pathways through which environmental
131 regulation affects economic growth. Scholars mainly focused on the mediating role or
132 influencing factors of environmental regulation on economic growth. Many scholars
133 found that environmental regulation policies can significantly promote high-quality
134 economic growth through the mediating role of industrial structure, resource allocation,
135 technological innovation, government intervention, energy consumption(Yang et
136 al.2020). Shi and Yi(2020) revealed that environmental regulation can promote high-
137 quality economic growth through quality and efficiency, structural regulation,
138 innovation drive, green development, livelihood protection, and Chen et al.(2021) used
139 firm-level data on environmental emissions and patent applications in China's textile
140 industry from 1998-2013 to find that green industrial policies affect the quality of
141 economic growth in heavily polluting industries through firms' environmental and
142 innovation performance and innovation direction.

143 Environmental interviews and central environmental protection inspection are
144 special forms of environmental regulation, and studies have either focused on the issue
145 of innovative compensatory effects(Li et al.2021), or used empirical methods to assess
146 their effects on the treatment of air or water pollution(Liu et al.2021;Pan et al.2022;Liu
147 and Wu; Wang et al,2019;Lu 2022), or explore their impact on corporate environmental
148 information disclosure and corporate environmental performance(Shen and Zhou
149 2017;Chen et al. 2019;Tu et al.2020;Pan and Hong 2022). This paper explores the
150 impact of environmental regulation on the high-quality development of companies and
151 its mechanism of action based on a quasi-natural experiment of environmental
152 protection interview and environmental protection inspection, and objectively evaluates
153 the micro-economic effects of environmental protection interview. Compared with
154 previous literature, it attempts to make marginal contributions in the following three
155 aspects: First, the research content explores the impact of environmental protection
156 interview and environmental protection inspection on high-quality economic growth,
157 expanding the research on the impact of environmental regulation on the high-quality
158 development of companies at the micro level. Second, in terms of research methodology,
159 a multi-period difference-in-difference (DID) method is used to identify the net and
160 combined effects of the two on the high-quality development of companies, and a
161 propensity score-matched difference-in-difference-method (PSM-DID) is used to
162 conduct robustness tests, effectively avoiding the problem of endogeneity among the
163 variables. Thirdly, based on studying the effects of environmental protection interview
164 and environmental protection inspection on high-quality economic growth separately,
165 the interaction term between the two is introduced to explore the impact of the two
166 policies' two-pronged synergistic mechanism on high-quality economic growth, and the
167 impact of heterogeneous factors on the policy effects is analyzed in-depth, with a view

168 to contribute to the construction of a joint governance mechanism for multiple
169 environmental policies.

170 **Theoretical hypothesis**

171 An environmental interview is a process in which the Ministry of Environmental
172 Protection puts forward rectification requirements and rectification deadlines for the
173 problems in the interviewed city, and the interviewed party takes a position on the
174 rectification requirements. The interviewed area is required to submit a rectification
175 plan to the Ministry of Environmental Protection within 15 one working day of the
176 interview and submit it to the provincial people's government. The Ministry of
177 Environmental Protection (MEP) gives a maximum time limit of six months for
178 rectification, taking into account the progress and difficulty of the rectification. As can
179 be seen, environmental interviews are a new and flexible means of monitoring and
180 warning by putting pressure on local government officials. Environmental interviews
181 do not only target established environmental violations, but also focus on early warning
182 of outstanding local environmental hazards, environmental interviews contain a dual
183 function of post-event enforcement and punishment and pre-event supervision and
184 warning, which is conducive to source prevention and control, process management,
185 and risk restraint in the government's decision-making process in environmental matters
186 (Zhang and Zhang 2019). Environmental interviews focus on the supervision of
187 emissions companies, monitoring the pernicious impact of local companies' emissions
188 on local environmental quality, curbing heavy pollution behavior, promoting
189 technological innovation and transformation and upgrading of companies, and
190 improving environmental pollution, while enabling local companies and local
191 governments to reach consensus on environmental protection through democratic
192 consultation and improving the quality of economic growth, which shows that this soft
193 interview can be conducted not only within the environmental protection system.
194 Although not highly effective externally, they are a strong deterrent to illegal companies,
195 and the continued pressure on environmental protection forces companies to innovate
196 in products and technologies, thereby reducing costs and achieving a compensatory
197 effect of innovation, ultimately achieving a 'win-win' for both the environment and the
198 economy. Because of this, this paper proposes the first hypothesis.

199 H1: Environmental protection interview can effectively mitigate the "non-
200 complete implementation" of China's environmental legislation in practice through
201 environmental enforcement monitoring, and achieving high-quality economic growth.

202 The central environmental protection inspection has become a powerful tool to
203 reverse local inaction in environmental governance. Firstly, the central environmental
204 protection inspection is a leading group on environmental governance set up by the
205 State Council at random to inspect local governments and party and government cadres
206 on behalf of the central high level, elevating environmental inspection to an
207 unprecedented political level (Zhang and Zhang 2019).; secondly, the head of the
208 central environmental protection inspectorate is mainly a provincial or ministerial-level
209 cadre such as the director of each special committee of the National People's Congress
210 and the National Committee of the Chinese People's Political Consultative Conference,
211 and the public and media can use specific channels to At the end of the inspection, the

212 team reported major problems to the central government and ordered the local
213 government to draw up a rectification plan according to the inspector's requirements
214 and submit it to the State Council, effectively avoiding the inefficiency of law
215 enforcement brought about by information asymmetry(Wang et al.2019). This has
216 created strong political pressure on the local parties and government cadres. The central
217 government, the Ministry of Environmental Protection, local environmental protection
218 departments, the public, and the social media have played the game many times, and
219 through the environmental protection departments, in conjunction with the public
220 security authorities, they have pursued administrative or criminal responsibility for
221 environmental violations by units or individuals, making the central environmental
222 protection inspection a hard binding force to push the environmental protection
223 departments to effectively implement environmental policies. Because of this, this
224 paper proposes the second hypothesis.

225 H2: By inspecting local party officials and companies, central environmental
226 inspection can induce high-quality economic growth in the inspected companies.

227 Due to the lack of rigid constraints on environmental protection interviews, the
228 lack of mandatory, making the interview process there is a lack of rectification,
229 responsibility shifted to lower levels, or even to listen to reports instead of interviews,
230 the requirements proposed vague, targeted and less effective, and therefore difficult to
231 play a warning role to cadres. The environmental protection inspection will
232 undoubtedly put this monitoring mechanism into practice, as the inspection team will
233 hold local governments and their relevant departments accountable for outstanding
234 local environmental problems, breaking down the barriers to environmental
235 responsibility that exist in the local environmental governance system (Shen and Zhou
236 2017; Tu et al.2020). Secondly, after clarifying aspects of environmental pollution
237 prevention and control at source, process management, and risk restraint in
238 environmental protection interviews, environmental protection inspection with their
239 authority and political height effectively urge local implementation of environmental
240 policies to maximize the efficiency and strength of environmental policy
241 implementation in the short term and to take action on environmental issues. Finally,
242 the soft binding force of environmental interviews is applied before, during, and
243 afterward, effectively circumventing the rigid binding force of the central
244 environmental inspection, such as the temporary suspension of production and other
245 "one-size-fits-all" behavior of companies. In view of this, this paper proposes the third
246 hypothesis.

247 H3: Environmental protection interview and central environmental protection
248 inspection build a strong monitoring mechanism for environmental enforcement,
249 promote the effective implementation of environmental protection policies, and
250 facilitate high-quality economic growth of companies.

251 **Materials and methods**

252 **Data source**

253 This article selected data from 2010 to 2019 for Chinese A-share listed industrial
254 companies. And the following treatments are applied to them about previous literature.

255 Firstly, to avoid the effect of outliers, companies with outliers in their financial position,
256 such as ST, *ST, and PT, were removed from the raw data. Then, companies with
257 significant missing data for the main variables were excluded and the missing values
258 for individual variables were interpolated. Finally, to eliminate the effects of extreme
259 values, the main continuous variables were tail-limited at the 1% level. The company-
260 level data are mainly sourced from the Wind database, and are collated and
261 supplemented with company annual reports. Data on environmental protection
262 interview and central environmental protection inspection were mainly collected
263 manually by referring to relevant policy documents issued by local governments and
264 current affairs news, while other sample data were mainly obtained from the China
265 Statistical Yearbook, etc. After a series of screening and processing, an unbalanced
266 panel data of 14,789 observations was obtained.

267 **Variables**

268 **Explanatory variables**

269 The definition and measurement of high-quality development of companies have
270 not yet formed a unified cognition in academic circles. Referring to the previous
271 research (Acemoglu and Murat.2019; Liu et al. 2020), this paper adopts the total factor
272 productivity (TFP) of companies as an alternative indicator of high-quality economic
273 growth, uses the values calculated by the (Levinsohn-Pertin) LP method for basic
274 regression analysis, and uses the values calculated based on the (Olley and Pakes) OP
275 method for the robustness inspection. We use the symbol Y_{it} to denote TFP.

276 **Core explanatory variables**

277 The use of quasi-natural experiments to examine the effects of environmental
278 regulation implementation has been a common approach in recent years, and
279 environmental interviews as exogenous shocks provide the opportunity for quasi-
280 natural experiments using the difference-in-difference method. Both the time fixed
281 effect and the company fixed effect are controlled. We select environmental protection
282 interview (EPI) and central environmental protection inspection (CEPI) as proxy
283 variables for environmental regulation, while introducing the interaction term between
284 environmental protection inspection and environmental interviews and environmental
285 protection inspection as proxy variables for environmental regulation in the regression
286 model. We use the symbol Er to denote environmental regulation.

287 **Control variables**

288 Based on a review of the previous literature, the following variables were selected
289 as the control variables of the model, Table 1 shows the variables used in the model and
290 their descriptive statistics.

291 The main firm-level control variables affecting total factor productivity include:
292 gearing (Lev), expressed as total liabilities as a percentage of total assets; return on net
293 assets (Roa), expressed as the ratio of profit after tax to net assets; firm size (Size),
294 expressed as the natural logarithm of total assets; Tobin's Q, expressed as the ratio of
295 the market value of the firm to the replacement cost of its assets; equity Concentration
296 (Cr), measured as the share of the top shareholder in the total shares of the firm; Age of
297 the firm (Age), expressed as the age of the firm as at the current period.

298 Provincial-level control variables affecting total factor productivity are selected as
 299 the level of economic growth and the total urban population, both logarithmicized.

300

Table 1 Descriptive statistical results of main variables

Variables	Variable symbols	Number of samples	Average value	Standard deviation
Total Factor Productivity	TFP	14789	8.053	0.967
EPI	Er ₁	14789	0.178	0.383
CEPI	Er ₂	14789	0.211	0.408
Gearing ratio	Lev	14789	0.412	0.226
Return on net assets	Roa	14789	0.043	0.069
Business size	Size	14789	22.101	1.262
Tobin's Q	Q	14774	0.083	1.956
Concentration of shareholding	Cr	14789	34.777	14.699
Age of business	Age	14789	16.393	5.554
GDP per capita	Lgdp	14789	10.952	0.469
Total population	Lpeo	14789	3.985	0.639

301 Model

302 Differences in the total factor productivity of firms after the environmental
 303 interviews arise from three sources: time effects, attribute differences, and policy effects.
 304 The time effect refers to the characteristic that the total factor productivity of firms in
 305 the city changes over time even if the city is not interviewed; the attribute difference
 306 refers to the fact that the characteristics of different industries affect the total factor
 307 productivity of firms. And the policy effect refers to the change in total factor
 308 productivity caused by the environmental interviews. Considering that environmental
 309 interview has a policy radiating effect on the province where the region is located, the
 310 study was conducted in the province where the city being talked about is located.

311 To accurately identify the net effect of environmental interview on the total factor
 312 productivity of listed industrial companies, this paper uses a time-point inconsistent
 313 multi-period difference-in-difference method for estimation, which began in Hengyang,
 314 Hunan Province in January 2014 and then gradually spread to other cities. A benchmark
 315 regression model is constructed as follows:

$$316 Y_{it} = \beta_0 + \beta_1 Er_{1jt} + \beta_2 X_{it} + v_i + \gamma_t + e_{it} \quad (1)$$

317 where the difference-in-difference term $Er_1 = treat_1 * time_1$, and the listed
 318 industrial companies are divided into two groups: those in heavily polluting industries
 319 and those in other industries; since listed companies in heavily polluting industries are
 320 the key targets of supervision by local governments after being interviewed about
 321 environmental protection, listed companies in heavily polluting industries are treated

322 as a treatment group with a $treat_1$ value of 1 and listed companies in other industries
 323 are treated as a control group with a $treat_1$ value of 0. The subscripts i and j denote
 324 the listed industrial companies and the listed industrial companies' industries,
 325 respectively. The subscripts i and j denote the industry to which the listed industrial
 326 companies belong, respectively. The $time_1$ denotes the province that was interviewed
 327 about environmental protection during the sample period and takes the value of 1,
 328 otherwise it takes the value of 0. The time dummy variable denotes that the year belongs
 329 to the year in which the environmental protection interview took place and the
 330 subsequent years and assigns the value of 1, otherwise it takes the value of 0.

331 Y_{it} is the explanatory variable, specifically total factor productivity; the core
 332 explanatory variables are; X_{it} is a set of control variables, including firm-level gearing,
 333 return on net assets, firm size, Tobin's Q, equity concentration and province-level GDP
 334 per capita and population, v_i is a firm fixed effect, γ_t is a time fixed effect and e_{it}
 335 is a random error term. The coefficient β_1 is the focus of attention in the model, and
 336 its magnitude and sign directly reflect the net effect of environmental interview. β_1
 337 should be significantly positive if environmental interview have a catalytic effect on
 338 the quality of companies.

339 Similarly, the central environmental protection inspection (CEPI) has gradually
 340 been carried out to other cities since they started in Hebei Province in January 2016,
 341 and given that the timing of the CEPI is not uniform, the multi-period difference-in-
 342 difference method with inconsistent timing is still used to assess the policy effects of
 343 the CEPI. A benchmark regression model was constructed as follows.

$$344 \quad Y_{it} = \alpha_0 + \alpha_1 Er_{2jt} + \alpha_2 X_{it} + v_i + \gamma_t + e_{it} \quad (2)$$

345 Where the sign $Er_2 = treat_2 * time_2$, $time_2 = 1$ after a province is inspected,
 346 otherwise $time_2 = 0$. The rest of the variables have the same meaning as a model (1).
 347 The coefficient α_1 in model (2) is the important regression coefficient, the magnitude
 348 and sign of its value directly reflect the net effect of the central environmental protection
 349 inspection. α_1 should be significantly positive if the central environmental protection
 350 inspection has a catalytic effect on the high-quality development of companies.

351 Does the interaction term of the two policies of environmental protection interview
 352 and central environmental protection inspection have a better effect on high-quality
 353 economic growth than individual policies? To test the joint effect of environmental
 354 protection interview and central environmental protection inspection on high-quality
 355 economic growth, listed companies in heavily polluting industries in provinces that do
 356 not jointly implement environmental protection interview and central environmental
 357 protection inspection are used as the control group, otherwise they are the experimental
 358 group.

$$359 \quad Y_{it} = \theta_0 + \theta_1 Er_{3jt} + \theta_2 X_{it} + v_i + \gamma_t + e_{it} \quad (3)$$

360 And the $Er_3 = treat_3 * time_3$. If a province is both interviewed about
 361 environmental protection and subject to a central environmental protection inspection
 362 in year t , then $Er_3=1$, otherwise $Er_3=0$. θ_1 is a cross-term coefficient reflecting the
 363 impact of the two-pronged approach of environmental interviews and central

364 environmental protection inspection on high-quality economic growth.

365 **Results**

366 **Environmental interviews and high-quality economic growth**

367 1 Baseline regression results

368 Table 2 reports the results of the baseline regression of model (1), which is shown
 369 in column (1). The regression results in Table 2 show that after controlling for the effects
 370 of other factors, the sign of the coefficient of the difference-in-difference term is
 371 significantly positive and the net effect of environmental interview on the total factor
 372 productivity of firms is significantly positive, i.e. environmental interview significantly
 373 contribute to the high-quality economic growth of firms.

374 Table 2 The effect of environmental interviews regression results

Variable name	TFP_LP	TFP_OP	TFP_LP
Er _i	0.0301** (0.0145)	0.0477*** (0.0119)	0.0409*** (0.0154)
Lev	0.3642*** (0.0506)	0.5760*** (0.0345)	0.3537*** (0.0523)
Size	11.5643*** (0.2713)	4.0688*** (0.1081)	11.6598*** (0.2923)
Roa	1.4064*** (0.1163)	2.0577*** (0.1089)	1.3099*** (0.1214)
Q	-0.0054 (0.0038)	-0.0322*** (0.0028)	-0.0026 (0.0041)
Age	0.0034* (0.0019)	-0.0044*** (0.0008)	0.0059*** (0.0021)
Cr	-0.0557*** (0.0207)	-0.0454*** (0.0095)	-0.0856*** (0.0237)
Lgdp	0.0684*** (0.0171)	0.0341*** (0.0068)	0.1200*** (0.0223)
Lpeo	0.0006 (0.0007)	0.0007** (0.0003)	0.0011 (0.0008)
Constant	-27.6764*** (0.8351)	-8.8987*** (0.3318)	-27.9264*** (0.9002)

Observations	14,774	14,755	12,596
R ²	0.4903	0.3072	0.4955
Time fixed effects	YES	YES	YES
Individual fixed effects	YES	YES	YES

375 Note: ***, **, and * denote significance levels of 1%, 5%, and 10% respectively; values in brackets are robust
376 standard errors of clustering and "YES" indicates controlling for firm and year fixed effects, as below.

377 2 Robustness tests

378 To ensure the robustness of the study results, this section focuses on robustness
379 testing by replacing the explanatory variables, excluding samples of different levels,
380 parallel trend tests, and placebo tests.

381 Column (3) of Table 2 shows the results of the DID regression using the total factor
382 productivity of companies measured by the OP method as the dependent variable,
383 indicating that environmental interviews significantly contribute to the high-quality
384 economic growth of companies in the interviewed areas. Taking into account the
385 differences in administrative level, economic size, and resource endowment between
386 municipalities directly under the central government and prefecture-level cities, the
387 coefficients of Er_1 were re-estimated after excluding firm-related data from Beijing,
388 Tianjin, Shanghai, and Chongqing regions based on full sample, the coefficient of Er_1
389 is shown in the fourth column of Table 2, which is basically consistent with the
390 benchmark regression results. The use of the DID method requires the parallel trend
391 test to be satisfied, i.e. the trend in the movement of total factor productivity should
392 remain broadly consistent between the control and experimental groups in the absence
393 of external shocks. To test whether the total factor productivity of the treatment and
394 control groups satisfy the parallel trend hypothesis, the following regression model is
395 set up on the basis of model (1).

$$396 \quad Y_{it} = \beta_0 + \sum_b \beta_b \text{Before}_{jb} + \beta_1 \text{Curren}1_{jt} + \sum_a \beta_a \text{After}_{ja} + \alpha X_{it} + v_i +$$

$$397 \quad \gamma_t + e_{it}$$

398 (4)

399 Where b denotes the impact generated in period b before treatment, a denotes
400 the impact generated in period a after treatment, and the coefficient β_1 denotes the
401 impact generated in the current period of treatment, i.e. the dummy variable takes the
402 value of 1 when a year is a treatment period, otherwise it takes the value of 0. Other
403 symbols have the same meaning as in model (1).

404 The second column of Table 3 reports the results of the test, which show that there
405 is no significant difference in the trend of total factor productivity between the treatment
406 and control group firms in the four periods before the implementation of the
407 environmental interview. The following conclusions are drawn: the hypothesis of
408 parallel trends holds and the sample firms in the treatment and control groups have the
409 same trends before the environmental interview.

410 Table 3 Parallel trend test and placebo test

Variable name	TFP_LP	Variable name	TFP_LP
d_4	0.0040 (0.0223)	Er ₁	0.0154 (0.0113)
d_3	0.0258 (0.0185)	Lev	0.6809*** (0.0274)
d_2	0.0051 (0.0148)	Size	0.0024*** (0.0003)
d_1	-0.0090 (0.0109)	Roa	-0.0203*** (0.0027)
Current	0.0206** (0.0094)	Q	-0.0004 (0.0008)
a ₁	0.0252* (0.0144)	Age	0.5543*** (0.0046)
a ₂	0.0513** (0.0166)	Cr	2.3792*** (0.0713)
a ₃	0.0321 (0.0221)	Lgdp	0.0230** (0.0097)
a ₄	0.0230** 0.0102	Lpeo	0.0017*** (0.0001)
Constant	-2.1711** (0.7090)	Constant	-4.9809*** (0.1364)
Observations	14,774	Observations	14,774
R ²	0.5122	R ²	0.6977
Individual fixed effects	YES	Time fixed effects	YES
Time fixed effects	YES	Individual fixed effects	YES

411 In fact, other policies or unobservable influences besides the environmental
412 protection interview also cause changes in firms' total factor productivity over the
413 sample period, so changes in total factor productivity may not be related to the
414 environmental protection interview. The placebo test is carried out by varying the
415 timing of the environmental interview, i.e. by advancing the timing of the
416 environmental interview by two years for each province. If the regression coefficient
417 of the environmental interview on total factor productivity is still significantly positive

418 at this point, it suggests that the growth in total factor productivity of firms in the
 419 interviewed areas may be influenced by other unobservable factors or policies, and not
 420 all of them are caused by the environmental interview. Column (4) of Table 3, the
 421 estimated coefficient of the difference-in-difference term is not significant after the
 422 policy is implemented two years earlier, suggesting that it was the environmental
 423 interviews that contributed to the high-quality economic growth of the companies
 424 during the sample period.

425 **Central environmental protection inspection and high-quality economic growth**

426 1 Baseline regression results

427 Table 4 reports the results of the regression for the model (2), and the benchmark
 428 regression results are shown in the second column. The sign of the coefficient of the
 429 difference-in-difference term in Table 4 is significantly positive, i.e. the central
 430 environmental protection inspection significantly contributed to the economic quality
 431 development of companies.

432 Table 4 Regression results of the policy effects of the central environmental protection inspection

Variable name	TFP_LP	TFP_OP	TFP_LP
Er ₂	0.0427*** (0.0145)	0.0551*** (0.0151)	0.0425*** (0.0155)
Lev	0.3759*** (0.0501)	0.2527*** (0.0531)	0.3662*** (0.0517)
Size	11.5280*** (0.2697)	4.1913*** (0.2690)	11.6178*** (0.2913)
Roa	1.3975*** (0.1159)	1.4975*** (0.1328)	1.2982*** (0.1211)
Q	-0.0054 (0.0038)	-0.0138*** (0.0026)	-0.0028 (0.0041)
Age	0.0009 (0.0019)	-0.0096*** (0.0020)	0.0030 (0.0021)
Cr	-0.0626*** (0.0206)	-0.2082*** (0.0197)	-0.0949*** (0.0234)
Lgdp	0.0694*** (0.0171)	0.0242 (0.0166)	0.1248*** (0.0224)
Lpeo	0.0006 (0.0007)	-0.0001 (0.0008)	0.0012 (0.0008)

Constant	-27.4697***	-7.2325***	-27.6874***
	(0.8290)	(0.8172)	(0.8960)
Observations	14,774	14,755	12,596
R ²	0.4908	0.1728	0.4955
Time fixed effects	YES	YES	YES
Individual fixed effects	YES	YES	YES

433 2 Robustness tests

434 To ensure the robustness of the study results, this section focuses on robustness
435 testing by replacing the explanatory variables, excluding samples of different levels,
436 parallel trend tests, and counterfactual tests.

437 Column (3) of Table 4 shows the results of a DID regression using total factor
438 productivity of companies measured by the OP method as the dependent variable,
439 indicating that environmental protection inspection significantly contributed to the
440 high-quality economic growth of companies in the interviewed regions. After re-
441 estimating the data by excluding companies in Beijing, Tianjin, Shanghai, and
442 Chongqing regions from the full sample, the coefficients of Er_2 are generally
443 consistent with the results of the baseline regression. To test whether the total factor
444 productivity of the treatment and control groups satisfy the parallel trend hypothesis,
445 the following regression model is set up on the basis of model (2).

$$446 Y_{it} = \theta_0 + \sum_b \theta_b Before_{jb} + \omega_1 Currer1_{jt} + \sum_a \theta_a After_{ja} + \rho X_{it} + v_i +$$

$$447 \gamma_t + e_{it} \quad (5)$$

448 Where b denotes the impact generated in period b before treatment, a denotes
449 the impact generated in period an after treatment, and the coefficient ω_1 denotes the
450 impact generated in the current period of treatment, i.e. the dummy variable takes the
451 value of 1 when a year is a treatment period, otherwise it takes the value of 0. Other
452 symbols have the same meaning as in model (1).

453 Table 5 reports the results of the test. In the four periods prior to the
454 implementation of the central environmental protection inspection, there was no
455 significant difference in the trend of total factor productivity between the treatment and
456 control groups of companies, which passed the parallel trend test.

457 Table 5 Parallel trend test and placebo test

Variable name	TFP_LP	Variable name	TFP_LP
d_4	-0.0018 (0.0259)	Er2	0.0036 (0.0035)
d_3	0.0462 (0.0290)	Lev	0.2310*** (0.0545)
d_2	0.0211	Size	-0.0003

	(0.0300)		(0.0008)
d_1	0.0342	Roa	0.0262**
	(0.0267)		(0.0120)
Current	0.0462*	Q	0.0044**
	(0.0251)		(0.0022)
a1	0.0626**	Age	0.2171***
	(0.0251)		(0.0127)
a2	0.0781***	Cr	1.3685***
	(0.0285)		(0.1296)
a3	0.0710***	Lgdp	0.0094
	(0.0112)		(0.0302)
a4	0.0486*	Lpeo	0.0007**
	(0.0289)		(0.0003)
Constant	-5.04**60	Constant	-1.3913***
	(0.1133)		(0.4064)
Observations	14,774	Observations	14,774
R ²	0.5122	R ²	0.3466
Individual fixed effects	YES	Time fixed effects	YES
Time fixed effects	YES	Individual fixed effects	YES

458 Similarly, a counterfactual test was conducted by varying the timing of
459 environmental protection inspection, i.e. regressing the timing of environmental
460 protection inspection two years earlier for each province respectively, the results are
461 presented in column (2) of Table 5. The estimated coefficients of the difference-in-
462 difference term are not significant after the policy implementation is advanced by two
463 years, which indicates the result that environmental protection inspection promote.

464 **Mixed policy and quality economic growth**

465 1 Baseline regression results

466 The results of the impact of environmental protection interview and environmental
467 protection inspection on high-quality economic growth are shown in Table 6. The
468 coefficient of the interaction term is 0.0500 and is significant at the 1% level, indicating
469 that the two-pronged approach of environmental interviews and environmental
470 protection inspection can significantly contribute to the improvement of total factor
471 productivity, and from the coefficient of the interaction term, the effectiveness of the
472 two policies in combating pollution is higher than the effect of individual policies.
473 Environmental interviews clarify environmental responsibilities through soft binding,

474 but do not guarantee the effective implementation of environmental policies, while
 475 environmental inspection effectively monitor the authority of the subject of the
 476 interview, solve outstanding environmental problems and implement environmental
 477 policies. The two will work together to promote the quality development of the
 478 enterprise economy.

479 Table 6 The effect of environmental protection interview and environmental protection
 480 inspection regression results

Variable name	TFP_LP	TFP_OP	TFP_LP	TFP_LP
Er3	0.0500*** (0.0120)	0.0748*** (0.0118)	0.0529*** (0.0130)	0.0856*** (0.0099)
Lev	0.3803*** (0.0503)	0.2606*** (0.0532)	0.3711*** (0.0519)	0.6555*** (0.0336)
Size	11.5062*** (0.2699)	4.1580*** (0.2681)	11.5923*** (0.2915)	0.0023*** (0.0003)
Roa	1.3933*** (0.1154)	1.4893*** (0.1321)	1.2919*** (0.1206)	-0.0206*** (0.0030)
Q	-0.0049 (0.0038)	-0.0131*** (0.0026)	-0.0023 (0.0041)	0.0015* (0.0009)
Age	-0.0002 (0.0020)	-0.0117*** (0.0020)	0.0018 (0.0021)	0.5602*** (0.0051)
Cr	-0.0681*** (0.0205)	-0.2162*** (0.0197)	-0.1008*** (0.0235)	2.3376*** (0.1120)
Lgdp	0.0691*** (0.0171)	0.0238 (0.0167)	0.1257*** (0.0225)	0.0415*** (0.0106)
Lpeo	0.0007 (0.0007)	-0.0000 (0.0007)	0.0012 (0.0008)	0.0020*** (0.0001)
Constant	-27.3330*** (0.8296)	-7.0235*** (0.8160)	-27.5387*** (0.8982)	-5.3138*** (0.1529)
Observations	14,774	14,755	12,596	14,610
R ²	0.4917	0.1770	0.4965	0.6988
Time fixed effects	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES

481 2 Robustness tests

482 This section focuses on robustness testing using the replacement of explanatory
 483 variables, exclusion of samples of different levels, and propensity score matching-
 484 difference in difference (PSM-DID) tests.

485 Column (2) of Table 6 shows the results of the DID regression using total factor
 486 productivity of companies measured by the OP method as the dependent variable,
 487 indicating that environmental protection inspection significantly contributed to the
 488 high-quality economic growth of companies in the interviewed regions. The
 489 coefficients of Er_3 are generally consistent with the results of the benchmark
 490 regression after re-estimation by excluding the data of companies in Beijing, Tianjin,
 491 Shanghai, and Chongqing regions from the full sample. The DID method can well solve
 492 the endogeneity problem, but cannot overcome the problems caused by biased sample
 493 selection, while the propensity score matching (PSM) method can better solve the
 494 influence of individual differences on the research results, so the combination of both
 495 methods is used to reduce the estimation bias of the DID model by performing
 496 estimation after solving the problem of sample selection bias.

497 Propensity scores were estimated by logit models, and the observable control
 498 variables in the experimental and control groups within the sample period were matched
 499 using a matching method with $k=1$ within calipers to determine weights, with the
 500 Common condition imposed, i.e. nearest neighbor matching for individuals within the
 501 common range of values only. After matching, it was tested whether the distribution of
 502 variables between the experimental and control groups was balanced and whether the
 503 means of the covariates remained significantly different between the experimental and
 504 control groups. If there is no significant difference, it indicates that the selected
 505 matching variables and matching method are appropriate and the results of the
 506 difference-in-difference estimation based on this are convincing. The results of the
 507 balance test are shown in Table 7, where the absolute value of the standard deviation of
 508 each matching variable is less than 5%, i.e. there is no significant difference between
 509 the experimental and control groups. Further, the DID estimation results after matching
 510 are reported in column (5) of Table 6, with a regression coefficient of 0.0856 and
 511 significant at the 1% statistical level. The interaction term between environmental
 512 protection interviews and the central environmental protection inspection still has a
 513 significantly positive impact on the high-quality development of the enterprise
 514 economy, and the study findings remain robust after eliminating individual differences.

515

Table 7. Balance test results

Variables	Processing	Average value		Deviation rate %	Deviation reduction ratio	t-test	
		Processing group	Control group			t	$p> t $
<i>Lev</i>	U	0.4128	0.4092	1.8		0.90	0.370
	M	0.4128	0.4133	-0.3	55.1	-0.33	0.738
<i>Size</i>	U	3.1094	3.0906	33.6		16.90	0.000
	M	3.1094	3.109	0.6	98.1	0.24	0.812

<i>Roa</i>	U	0.0450	0.0423	3.8		1.93	0.053
	M	0.0450	0.0439	1.5	60.5	0.62	0.535
<i>Q</i>	U	1.7267	2.2134	-27.5		-12.92	0.000
	M	1.7267	1.7558	-1.6	94.0	-0.76	0.446
<i>Age</i>	U	19.011	15.743	62.9		30.42	0.000
	M	19.011	19.016	-0.1	99.8	-0.04	0.968
<i>Cr</i>	U	33.8580	34.902	-7.2		-3.54	0.000
	M	33.8580	34.143	-2.0	72.7	-0.76	0.44
<i>Lgdp</i>	U	11.098	11.013	39.2		18.59	0.000
	M	11.098	11.125	-6.3	83.9	-2.64	0.008
<i>Lpeo</i>	U	3.9850	3.9925	-1.2		-0.59	0.555
	M	3.9850	3.9852	-0.0	96.9	-0.01	0.989

516 Heterogeneity test

517 Heterogeneity of business ownership test

518 This section focuses on the examination of the heterogeneity of the synergistic
519 mechanisms between environmental interviews and central environmental protection
520 inspection. The regression results for the sub-sample by ownership type are shown in
521 Table 8. The synergy mechanism has a significant contribution to the economic quality
522 development of both SOEs and non-SOEs, but the contribution is greater for non-SOEs.
523 There are two specific reasons for this: First, the companies have different objectives.
524 When the intensity of environmental regulations increases, non-state companies need
525 to promptly implement pollution control and bring into play the effects of innovation
526 to absorb the increased compliance costs. Secondly, there are differences in the external
527 institutional environment. State-owned companies enjoy the advantages of more
528 subsidies from local governments and low-cost financing, and are easily sheltered by
529 local governments, so the pressure of rising compliance costs is relatively low, while
530 non-state-owned companies have fewer advantages, and companies need to reduce
531 compliance costs by improving marginal efficiency, thus promoting high-quality
532 economic growth (Liu et al.2020).

533 Table 8 .Regression results of companies with different ownership types

Variable name	State-owned	Non-State
Er ₃	0.0369*** (0.0134)	0.0460*** (0.0100)
Lev	0.2993***	0.4188***

	(0.0406)	(0.0300)
Size	0.0001	0.0011**
	(0.0006)	(0.0004)
Roa	-0.0144***	-0.0057***
	(0.0041)	(0.0020)
Q	-0.0111***	0.0013
	(0.0031)	(0.0017)
Age	0.4870***	0.5214***
	(0.0100)	(0.0070)
Cr	1.5339***	1.3860***
	(0.0852)	(0.0543)
Lgdp	0.0174	-0.0418**
	(0.0302)	(0.0189)
Lpeo	0.1010***	0.0654***
	(0.0337)	(0.0168)
Constant	-3.2271***	-3.5919***
	(0.3653)	(0.2297)
R ²	0.4234	0.5069
Observations	5,023	9,751
Time fixed effects	YES	YES
Individual fixed effects	YES	YES

534 **Regional heterogeneity test**

535 The results are shown in Table 9: after controlling for other influencing factors,
536 the synergy mechanism significantly contributes to the high-quality development of
537 companies in the eastern region. A well-developed and systematic innovation
538 environment is more conducive to the implementation of environmental policies and is
539 more likely to increase the innovation efforts of companies, thus effectively
540 contributing to the improvement of their total factor productivity levels (Liu and He
541 2019).

542

Table 9 Regression results of companies with different regions

	(1)	(2)	(3)
Variable name	East	Central	Western

Er3	0.0984*** (0.0255)	0.0286* (0.0159)	0.0564*** (0.0098)
Lev	0.4106*** (0.0295)	0.3162*** (0.0480)	0.2802*** (0.0630)
Size	0.0002 (0.0004)	-0.0030*** (0.0007)	0.0020* (0.0011)
Roa	-0.0036* (0.0021)	-0.0186*** (0.0040)	-0.0090* (0.0052)
Q	0.0038** (0.0019)	0.0040 (0.0042)	-0.0015 (0.0063)
Age	0.5333*** (0.0067)	0.1857*** (0.0122)	0.4930*** (0.0175)
Cr	1.3732*** (0.0553)	1.8013*** (0.0994)	1.0554*** (0.1262)
Lgdp	-0.1338*** (0.0233)	-0.4212*** (0.0423)	-0.0872 (0.0581)
Lpeo	0.0436** (0.0190)	-0.0007 (0.0658)	0.0185 (0.0417)
Constant	-2.6948*** (0.2767)	3.7271*** (0.5044)	-2.3409*** (0.6201)
R ²	0.5228	0.2163	0.4179
Observations	9,824	2,934	1,803
Individual fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES

543 Conclusion

544 Based on data from domestic A-share listed companies from 2010 to 2019, this
545 study uses a multi-period double-difference approach to evaluate the policy effects of
546 environmental protection interview and central environmental protection inspection
547 and the combination of the two, respectively. The results show that both environmental
548 protection interview and central environmental protection inspection can promote high-
549 quality development of industrial companies in heavily polluting industries, and this

550 result is also supported by parallel trend tests and placebo tests, among others. Overall,
551 the two-pronged policy effect of environmental interviews and central environmental
552 protection inspection is more significant, and the promotion of high-quality
553 development of companies is higher than the net effect of the two policies. In terms of
554 heterogeneity, there are significant differences in the impact of the synergy mechanism
555 on the high-quality development of companies across different ownership and regions.
556 Specifically, non-state-owned companies are more sensitive to the synergy mechanism,
557 and regional heterogeneity analysis indicates that the effect of the synergy mechanism
558 on the high-quality economic growth of companies in the eastern region is stronger.
559 Based on the findings of the study, the following policy recommendations are made.

560 In terms of environmental enforcement, a long-term mechanism for monitoring
561 environmental enforcement should be established, with greater penalties for 'one-size-
562 fits-all' behavior. The central government needs to carry out occasional inspection visits,
563 or gradually develop the environmental enforcement system into a regular mechanism
564 in the section system, and develop environmental interview as part of China's
565 environmental monitoring system. To achieve an effective interface between
566 environmental protection interview and central environmental protection inspection, to
567 bring into play the effective role of the hard binding force of central environmental
568 protection inspection in environmental protection interview, and to increase the soft
569 binding force of environmental protection interview in central environmental protection
570 inspection, so that the soft binding force of the environmental protection interview
571 system and the rigid binding force of the central environmental protection inspector
572 mechanism are enhanced. In terms of policy development, differentiated policies are
573 set according to the different characteristics of regions and types of companies. Policies
574 should be revised on time according to the specific circumstances at the regional level
575 to further optimize the allocation of resources; companies should also adopt
576 differentiated strategies for technological innovation based on ownership type and
577 resource endowment of the region. In terms of public participation, establish open and
578 effective channels for public and media participation. A permanent website, mailbox,
579 and hotline can establish a regular mechanism for public participation in environmental
580 pollution control and maximize public and media oversight.

581 **Ethical Approval**

582 Not applicable. This study has no ethical implications.

583 **Consent to Participate**

584 Not applicable.

585 **Consent to Publish**

586 Not applicable.

587 **Authors Contributions**

588 ZYB designed the study, collected the data and edited the manuscript. LX an
589 alyzed the data, performed the experiments. All authors read and approved the

590 final manuscript.

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594 **Competing Interests**

595 The authors declare that they have no conflict of interest.

596 **Availability of data and materials**

597 The datasets used and/or analyzed during the current study are available from t
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