



Environmental decentralization, local governments' environmental attention and environmental pollution: an empirical evidence from establishment of River Chief System in China

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Abstract

The optimization of the environmental management system holds the key to environmental improvement. Despite extensive studies in the past years, it is still an open question whether environmental policies should be centrally enforced. Thus, this paper, based on clarifying the relationship between environmental decentralization (ED) and river chief system (RCS), will elucidate the theoretical mechanism of the impact of ED on environmental pollution from the perspective of local governments' environmental attention (LGEA). In addition, based on the panel data of 108 cities in the Yangtze River Economic Belt from 2003 to 2018, it will take the establishment of RCS as a quasi-natural experiment to explore the effect of ED on environmental pollution and the mediating effect of LGEA with the difference-in-difference method. The results show that ED exerts a lagged effect on reducing environmental pollution, and the effect increases over time. In terms of heterogeneity, the effect of ED on environmental pollution is immediately negative, and the negative effect increases over time in cities with high fiscal decentralization, but the effect is immediately positive and the positive effect decreases over time in cities with low fiscal decentralization. Lastly, the test of mediating effect indicates that ED can ultimately reduce environmental pollution by raising LGEA. This paper provides a new perspective for understanding the impact of ED on emission reduction.

Keywords Environmental decentralization · Local governments' environmental attention · Environmental pollution · River Chief System · Yangtze River Economic Belt

1 Introduction

Despite its largest population in the world, China has delivered remarkable economic progress over the past 40 years. This success is often explained by the meritocratic promotion mechanism, in which officials with the higher GDP growth rate in their jurisdiction are promoted, and local governments compete for economic growth (Yu et al., 2016). The effective operation of this mechanism is closely related to China's unique pattern of political centralization and economic decentralization in the relationship between the central government

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and local governments and has served as a catalyst for the deteriorating environmental pollution. In fact, environmental pollution is an issue besetting many countries in the early and middle stages of urbanization and economic development. However, environmental pollution remains relatively serious in China, hampering its sustainable economic growth. According to the National Bureau of Statistics of China (<http://www.stats.gov.cn/>), in 2021, the emissions of water chemical oxygen demand (COD), SO₂, and particulate matter were 25.3098 million tons, 2.7478 million tons, and 5.376 million tons, respectively. Meanwhile, in the “2020 Environmental Performance Index” jointly issued by Yale University, Columbia University, and others, China ranked only 120th among 180 participating economies (<https://epi.yale.edu/>). The reason is that local officials with promotion incentives mainly on GDP growth had to set economic development as their priority (Yin & Wu, 2022). Due to the lack of necessary supervision, local officials tended to implement projects with short lead times and quick economic results, which inevitably sidelined the investment in environmental protection (Zhu et al., 2020). In particular, in the context of political centralization and economic decentralization, Chinese environmental management system is a “combination of the article and the block” (“articles” means that environmental bodies at higher levels provide necessary guidance to the local environmental bodies, and “blocks” means that local governments are responsible for financial budget and personnel arrangements of the local environmental bodies), in which authority and responsibility for environmental management are unclearly specified among various departments within local governments. What is obvious is that the level of regional environmental governance was influenced by the distribution of power and responsibilities between central and local governments (Zou et al., 2019). This issue is known as environmental decentralization (ED).

Environmental centralization (EC) or ED has long been a hot issue in environmental governance research, but scholars hold quite different views. Of various views, the core of environmental federalism is how to optimize the allocation of power and responsibility for environmental management among governments at varied levels (Cole et al., 2013), which was essentially the trade-off between the advantages and disadvantages of ED and EC. On the whole, some hold that ED is more effective in fighting pollution. Local governments were more familiar with the local demands (Garcia-Valiñas, 2007) and could tailor environmental policies according to local conditions (Falleth & Hovik, 2009). Thus, ED improved the allocation efficiency of administrative personnel and capital of environmental management (Oates, 2001) and environmental quality (Magnani, 2000). Second, EC system is more effective in pollution control. Early literature mostly examined environmental governance performance from the perspective of fiscal decentralization, finding that fiscal decentralization exacerbated environmental pollution (Kunze & Shogren, 2007). In terms of ED, given the public nature and externality of environmental pollution, the central government’s environmental policies weaken the strategic interaction behavior of local governments in environmental governance (Gray & Shadbegian, 2004), which in turn improved environmental governance performance (Banzhaf & Chupp, 2012), i.e., environmental governance was significantly improved in the context of EC (Helland & Whitford, 2003; Oyono, 2005). In this regard, Besley and Coate (2003) argue that the relative merits of decentralization and centralization ultimately depend on spillovers and inter-regional heterogeneity in tastes.

Because of the continued debate over whether environmental policies should be unified or centrally enforced, scholars have sought empirical evidence. Sigman (2014) provided evidence in favor of the idea that decentralization allowed better tailoring of policies to local conditions and thus improves economic efficiency. However, Grooms (2015) used an event study to examine the transition from federal to state management

of the clean water act and concluded that federal control of environmental policy was effective in states with corrupt institutions. In recent years, Chinese scholars have focused on empirical analysis of the effects of ED on economic growth and environmental pollution in the context of China's environmental management system. Qi et al. (2014) first used the number of personnel within the environmental protection system to measure the degree of ED in China. Following this method, some scholars found that decentralization of environmental management improved the local green development (Zou et al., 2019) by promoting corporate investment in environmental protection (Liu et al., 2022), carbon emission control (Xia et al., 2021), and environmental technology innovation (Guo & Jiang, 2022). But others thought that ED inhibited pollutants control (Lin & Xu, 2022) and green total factor productivity (Luo et al., 2023). The above disagreement suggests that there is an uncertain or nonlinear relationship between the effects of ED on environmental pollution (Zhang & Li, 2022). In addition, the effects of decentralization on environmental pollution varied from the types of decentralization including environmental administrative decentralization (EAD), environmental monitoring decentralization (EMD), and environmental supervision decentralization (ESD) (Liu & Yang, 2022; Wu et al., 2020a, 2020b). In terms of mechanism, previous literature has focused on the moderating role of environmental regulation (Liu et al., 2022), government corruption (Hao et al., 2021), and digital finance (Feng et al., 2022). Only a few pieces of literature have explored the mechanisms underlying the effect of ED on environmental pollution from two aspects of theory and empirical evidence (Fang & Cao, 2022).

River chief system (RCS), as a decentralized policy, has recently gained attention in China (Xu et al., 2022). Local government leaders are appointed as river chiefs holding responsibility for managing water resources and ecology within their jurisdiction. At the same time, local governments are given more authority and responsibility for reducing environmental pollution. The previous literature has examined the effectiveness of ED from the standpoint of the RCS policy in China (Li & Wang, 2020; Li et al., 2020; She et al., 2019). According to those papers, the RCS reduced environmental contamination by strengthening responsibility and collaboration among different departments within local governments. Under the RCS, local governments have to devote to economic development, environmental governance and other policy goals. Due to the time and resource constraints, local governments have to make trade-offs among these agendas, and this process is known as attention allocation (Bao & Liu, 2022). As far as we know, what has not yet been noticed is whether ED reduces emissions by improving local governments' environmental attention under the RCS, which is a focus of this paper.

In conclusion, existing literature on the RCS or ED has provided much food for thought. However, some of the overlooked issues are as follows.

Firstly, the net effects of decentralization on pollution control are uncertain (Sigman, 2014), which provides an opportunity to evaluate the empirical importance of China's Yangtze River Economic Belt. Previous studies often used the differences of it between provinces to explore the effects of ED, but rarely focused on the environmental system at the city level. Following Li and Wang (2020) and She et al. (2019) who exploited the cross-city and cross-year variations in the timing of the establishment of RCS, this paper explores the effect of ED on environmental pollution with the difference-in-difference (DID) method and the city level data. This paper finds that ED generally curbs environmental pollution in the Yangtze River Economic Belt. The effect of ED on environmental pollution is significantly negative in cities with high fiscal decentralization; however, it is significantly positive in cities with low fiscal decentralization.

Secondly, previous studies focused more on empirical tests of the effect of ED on pollutants control, but few touch upon the theoretical analysis and empirical tests of the internal mechanism affecting environmental pollution. Based on the attention theory, this research explores the internal mechanisms of ED affecting environmental pollution and tests the mediating role of local governments' environmental attention with the mediation model.

Finally, existing studies usually used the number of personnel within the environmental protection system to measure the degree of ED in China. However, this index is easily affected by local governments' financial capacity and other factors, and those factors may be endogenous for environmental pollution control. Thus, this paper tries to mitigate the endogeneity of effect estimates using DID and PSM-DID methods.

The marginal contributions of this study are as follows: First, this paper expands the extensive discussion on ED. It proposes an alternative perspective for understanding the advantages of ED, stemming from the attention theory. After clarifying the theoretical logic of the effect of local governments' environmental attention on environmental pollution, this study elucidates the theoretical mechanisms by which ED curbs environmental pollution from the perspective of local governments' environmental attention. Second, this paper deepens the understanding of the RCS policy. It explains the relationship between ED and RCS policy and analyzes the change in China's environmental governance system due to the implementation of the RCS, which provides a vivid case and reference for those developing countries whose ED has been declared a failure. Third, in terms of endogeneity, this paper collects RCS-related data on multiple websites, considers RCS implementation as a quasi-natural experiment for the establishment of ED system, and conducts an empirical study with the DID and PSM-DID method to minimize the endogeneity problem affecting the effect estimation results, which provides new empirical evidence for understanding the positive effect of ED on pollutants control. Lastly, this paper further explores the heterogeneous impacts of ED on environmental pollution among cities with different degrees of fiscal decentralization, which helps to further optimize China's environmental management system.

The rest of this paper is organized as follows. Section 2 explains the institutional background of RCS and the theoretical mechanism of ED affecting environmental pollution. Section 3 introduces the method, variable, and data. Section 4 presents the results of the empirical analysis. Section 5 concludes and proposes policy implications.

2 Institutional background and theoretical analysis

2.1 Institutional background

The Yangtze River Economic Belt is one of the most developed regions in China and has become a key area of ecological and environmental governance in China because of the Changjiang River, the longest river in China. According to *Guidance on the development of the Yangtze River Economic Belt on the basis of the golden*, this region covers two municipalities (including Shanghai and Chongqing) and nine provinces (such as Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Guizhou and Yunnan). In the past four decades, manufacturing has been strongly supported in this region, and also consumed water resources and produced a large amount of wastewater. Water pollution has become a serious problem in the regions along the Yangtze River. According to the National Bureau of Statistics, the total discharge of wastewater in the Yangtze River basin increased from

18.9 billion tons in 1998 to 34.67 billion tons in 2018. As a result, it is urgent to control water pollution in the Yangtze River Basin.

The environmental crisis in Taihu Lake is a microcosm of the increasing environmental pollution in the Yangtze River. The year 2007 saw the outbreak of the cyanobacteria crisis in Taihu Lake in Wuxi, resulting in the shortage of fresh water supply for citizens in Wuxi. The government of Wuxi creatively introduced the RCS policy to address the water pollution incident, i.e., leading officials at all levels were appointed as river chiefs to take responsibility for local water pollution control. In the context of RCS, local governments have placed a high priority on environmental governance, thus delivering effective water pollution control. The RCS policy of Wuxi sets a good example in the innovation of the ED system, which has been emulated by several local governments. In 2016, China's State Council proposed the establishment of RCS at the provincial, city, county, and township levels across China. By the end of 2017, this goal had been achieved within the Yangtze River Economic Belt. Figure 1 presents the cumulative number of sample cities implementing the RCS from 2003 to 2018.

In the past, the central government in China was responsible for making environmental policies, and local governments at all levels had to implement them (Li et al., 2021b). Policies for river pollution control in China were highly centralized (She et al., 2019). However, since the reform of the tax distribution system, the central government has mainly assessed the performance of local governments through economic development indicators, and local governments at all levels neglected environmental governance in their jurisdictions because of their high attention to economic development, which inevitably resulted in incomplete implementation of environmental policies. In the context of RCS, however, the central government appoints the heads of local governments as river chiefs who are granted coordination authority over the management of water environment in their jurisdictions. Moreover, local governments have been empowered with more responsibility for environmental protection and become the makers and implementers of environmental policies (Li

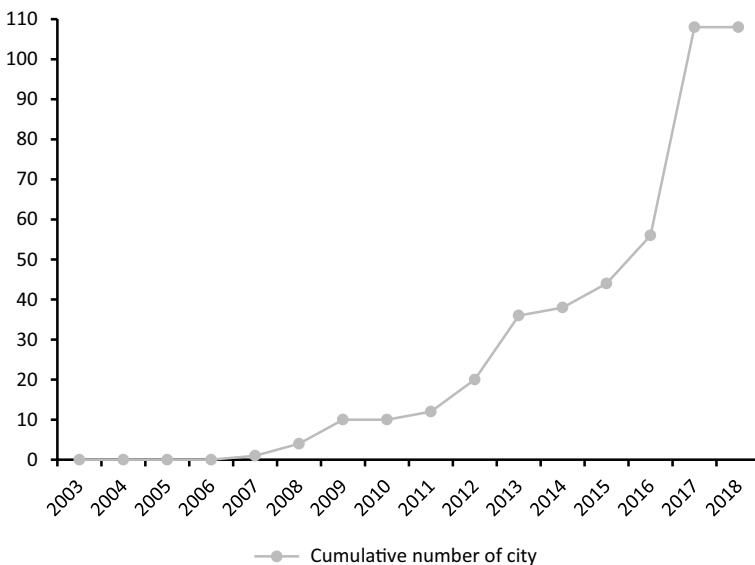


Fig. 1 Cumulative number of sample cities implementing the RCS from 2003 to 2018

& Wang, 2020). Therefore, the RCS is seen as a power delegation process from the central government to local governments, i.e., ED policy (She et al., 2019). Crucially, the collaboration among various departments within local governments has been optimized by raising the priority of environmental governance, which helps to reduce the “throw it over the wall”.

2.2 Mechanism analysis

This section focuses on the RCS (an ED policy) and explores the direct and indirect effects of ED on environmental pollution.

2.2.1 The direct impact of ED on pollutants control

The externality of environmental pollution results in market failure, which is a pressing problem of environmental governance. The mainstream view is that decentralization is the key to effectively solving environmental pollution (Oates, 2001). Firstly, the ED system provides local governments with greater autonomy in environmental protection spending, environmental protection personnel, and institutional setup, and provides incentives for local governments to develop innovative pollution control policies. The ED system provides local governments the opportunities to try these pollution control plans and to explore the most tailored measures, which will create more practical and effective environmental supervision and management systems and give full play to the role of a “national laboratory” (Millimet, 2014). Secondly, local governments have greater abilities to access environmental information (Millimet, 2003). Specifically, local officials are more familiar with the local ecological conditions due to their rich local experience. On the other hand, if local authorities directly supervise the environmental behavior of enterprises, it can reduce the difficulty of information collection and screening between the government and enterprises (Chen et al., 2022a). Under the RCS, local governments are permitted to directly regulate environmental pollution. Theoretically, they can develop and implement environmental regulatory policies fitting local conditions according to the information on the discharge situation of regional enterprises (D’Amato & Valentini, 2011). This advantage helps to strengthen the control of water pollution discharge in their jurisdiction. Finally, local governments have cost advantages in environmental management (Xu, 2011). The likelihood of resource misallocation is increased by the central government’s delay in collecting information (Dijkstra & Fredriksson, 2010). Local management of the environment reduces the intermediate cost of information transfer from the central to the local level, which reduces the cost of policy implementation (Wu et al., 2020a, 2020b). Therefore, ED promotes the rational allocation of funds for local environmental management and reduces unreasonable government intervention, which avoids interference with enterprise production and the waste of resources.

However, some hold that ED contributed to increasing pollution in some cases. First of all, Chinese local officials face financial and promotion incentives, which set lower environmental standards to attract investment (Fredriksson & Millimet, 2002). Second, the spillover of pollutants aggravates the difficulty of environmental governance, thus reducing the motivation of local governments in environmental governance and inducing hitchhiking behavior (Sigman, 2005). Under the RCS, the heads of local governments were appointed as river chiefs who have clear responsibilities for water environment management. More importantly, local water quality is linked to river chiefs’ promotion evaluation (Wang &

Xiong, 2022). Local governments have the pressure and motivation to water pollution control. In the long term, with the improvement of the RCS, local governments will gradually increase their attention to water environment management and take the initiative to circumvent inaction in environmental governance. ED can effectively leverage information advantages, cost advantages, and “national laboratory” effects to enhance the efficiency of environmental management and improve the quality of regional ecological environment.

Therefore, this paper proposes the first hypothesis:

H1 ED exerts a lagged positive effect on pollutants control, and the effect increases over time, i.e., RCS policy can inhibit water pollution in the long run.

2.2.2 The indirect effects of ED on environmental pollution

In China, local officials are evaluated by their superiors with multiple indicators. To respond to the concerns of the higher government, local authorities release government annual reports that summarize their achievements in the last year and set strategic objectives for the year ahead. These reports that clearly identify work priorities are often used to analyze the local governments’ attention allocation (Bao & Liu, 2022; Chen et al., 2022b; Zhao et al., 2022). Attention represents how much attention a decision maker attaches to a matter at a given time. According to the attention-driven policy selection model (Jones et al., 1993), the attention of local governments is a limited resource, and local governments have to set priorities among their objectives (Ocasio, 2011). If local governments focus on a certain field, it will inevitably affect policy making, government behavior, and reallocation of social resources in that field. Under the RCS system, while ED brings more autonomy to local governments, it also raises local governments’ concerns about environmental governance matters (Wang & Xiong, 2022). To be specific, the heads of local governments, rather than the environmental bodies, are primarily responsible for the water environment within the jurisdiction, which raises the priority of water environmental governance. Meanwhile, the water quality of rivers within the jurisdiction is closely related to the promotion of river chiefs, i.e., the performance in environmental governance is incorporated in the assessment of local officials (Li et al., 2020). These elaborate systems encourage local governments to increase their attention to environmental matters and to deploy more adequate financial resources and personnel for water pollutants control.

In this paper, we will analyze the internal mechanism of the impact of local governments’ environmental attention on environmental pollution from the following three aspects.

Firstly, as local governments pay more attention to environment, strict environmental regulation policies will be enforced (Chen et al., 2022b), which helps reduce emissions. On the one hand, local governments will conduct more frequent environmental inspections and increase penalties for pollution (Hao et al., 2018). Polluting enterprises will bear more social costs of pollution control (Sohn et al., 2015), thus reducing the investment in production and shrinking the output of polluting products in order to maintain the ideal profit. Meanwhile, moderate environmental regulation will guide highly polluting enterprises to innovate technologies (Liao & Shi, 2018), which reduce emissions per unit of product. On the other hand, local governments will implement a stricter environmental assessment and review system for new investment projects and promote the transfer of production factors from polluting industries to green industries with government subsidies (Lv et al., 2022; Wang et al., 2022a, 2022b),

which can directly reduce pollution emissions by reducing the production of high-pollution industries.

Secondly, with the increasing attention paid by local governments to the environment, companies will increase their investment in green production to gain strategic advantages, which contributes to pollution control. On the one hand, with increasing pressure on environmental protection, enterprises often take the initiative to achieve green production for avoiding policy risks (Chen et al., 2022b; Zhao et al., 2022). Green innovation holds the key to green production. Thus, enterprises increase investment in green innovation to reduce resource loss and emissions in the production process (Yan et al., 2022). On the other hand, to improve environment, local governments increase financial support for enterprises' environmental protection (Li & Chen, 2022). Enterprises that achieve green transformation and innovation can reap double dividends: they receive government subsidies, thus easing financial constraints; furthermore, they send out signals accredited by the governments for good investments, which helps obtain financial support from investors (Kleer, 2010). Rational businesses do so.

Thirdly, local governments' increasing attention to environment enlightens residents to pay more attention to environment (Lv et al., 2022). Residents actively participate in environmental supervision and management. Under strict public scrutiny, companies will actively carry out environmental protection activities to meet the public environmental demands and gain the favor of consumers (Luo et al., 2012; Matsumura et al., 2014). In addition, the share of green products in the market demand will expand, which will lead companies to develop green innovations and provide resource-efficient products (Kammerer, 2009).

In summary, ED has contributed to the formation of the environmental accountability system for local governments under the RCS policy. Local governments pay more attention to the environment and develop practical environmental management policies. Meanwhile, enterprises and the public are also involved in environmental management, playing a positive role in the control of pollutants.

Based on the above analysis, the following hypothesis is proposed:

H2 ED can indirectly decrease environmental pollution by increasing local governments' environmental attention, i.e., RCS policy will make local governments allocate more attention to environment and develop reasonable environmental policies, thus guiding enterprises and the public to participate in environmental governance, which in turn reduces environmental pollution.

3 Method, variable, and data

Based on the above theoretical analysis, this section attempts to do a research design on the relationship between ED, local governments' environmental attention and environmental pollution.

3.1 Model method

3.1.1 DID model

The DID method introduced by Ashenfelter in their evaluation of an intervention study is effective in assessing the effect of policies (Fu et al., 2021; Ge et al., 2022). In particular, existing studies for the RCS also examine the impact of ED on environmental pollution

with the DID method (Li & Wang, 2020; Li et al., 2020; She et al., 2019). The standard DID model can only be used to evaluate concurrent policies. However, policies are often not implemented in different regions at the same time. Therefore, Beck et al. (2010) proposed a time-varying DID model on the basis of the standard model. The principle is as follows:

First, the standard DID model is as follows:

$$Y_{it} = \alpha_0 + \beta_1 \text{time}_t + \beta_2 \text{treat}_i + \beta_3 \text{time} \times \text{treat}_i + \varepsilon_{it} \tag{1}$$

where Y_{it} represents the dependent variable. time_t is a time-varying variable. If year t belongs to policy implementation period, $\text{time} = 1$, otherwise $\text{time} = 0$. treat changes along with city i . If city i belongs to experimental group, $\text{treat} = 1$, otherwise $\text{treat} = 0$.

Second, before the policy was implemented, the conditional expectation of experimental group is as follows:

$$E(Y_{it} | \text{time} = 0, \text{treat} = 1) = \alpha_0 + \beta_1 \tag{2}$$

After the policy was implemented, the conditional expectation of experimental group is as follows:

$$E(Y_{it} | \text{time} = 1, \text{treat} = 1) = \alpha_0 + \beta_1 + \beta_2 + \beta_3 \tag{3}$$

Before the policy was implemented, the conditional expectation of control group is as follows:

$$E(Y_{it} | \text{time} = 0, \text{treat} = 0) = \alpha_0 \tag{4}$$

After the policy was implemented, the conditional expectation of control group is as follows:

$$E(Y_{it} | \text{time} = 1, \text{treat} = 0) = \alpha_0 + \beta_2 \tag{5}$$

Third, there is Eq. (6):

$$\beta_3 = [E(Y_{it} | \text{time} = 1, \text{treat} = 1) - E(Y_{it} | \text{time} = 0, \text{treat} = 1)] - [E(Y_{it} | \text{time} = 1, \text{treat} = 0) - E(Y_{it} | \text{time} = 0, \text{treat} = 0)] \tag{6}$$

In fact, the policy effectiveness is the difference in conditional expectation between the real event and the hypothetical event. (In the real event, the experimental group did implement the policy during the implementation period, while in the hypothetical event, the policy was not implemented.) β_3 is policy effectiveness.

This paper takes the establishment of RCS as a quasi-natural experiment and then explores the positive effect of ED on pollution control with the DID method. Nevertheless, the policy implementation period of RCS changes among different cities. Following Beck et al. (2010), this paper constructs a time-varying DID model with environmental pollution as the explained variable.

$$\text{Poll}_{it} = \alpha + \beta_1 \text{Ed}_{it} + \eta \text{Control}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \tag{7}$$

where Ed presents ED, which is interaction term of time and treat. If the city i has implemented the RCS policy in the year t , $\text{Ed} = 1$, otherwise it is 0. λ replaces time, which is a

year dummy variable. μ replaces treat, which is a city dummy variable. Control represents control variables. β_1 is the interesting coefficient that need to be estimated.

3.1.2 Event study model

As parallel trend assumption must be met when the time-varying DID model is adopted,

where there was no significant difference between the dependent variables of the experimental group, and the control group before the RCS was implemented. This paper explores the effect of ED with event study model (Beck et al., 2010).

$$\text{Poll}_{it} = \alpha + \sum_{k \geq -4, k \neq 0}^{10} \beta_n \text{Event}_{it}^k + \mu \text{Control}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (8)$$

where Event_{it}^k is a year dummy variable. This assumes that the year when city i establishes the RCS policy is recorded as year y_i , an set as $k = \tau - y_i$ and $\tau = t - 2003$. Meanwhile, when $k \leq -4$, $\text{Event}_{it}^{-4} = 1$, otherwise $\text{Event}_{it}^{-4} = 0$; when $k \geq 10$, $\text{Event}_{it}^{10} = 1$, otherwise $\text{Event}_{it}^{10} = 0$; when $k \in \{-2, -1\} \cup \{1, 2, 3, \dots, 10\}$, $\text{Event}_{it}^k = 1$. This set the year when city i establishes the RCS policy as the base period, and thus Event_{it}^0 is omitted in Eq. (8).

3.1.3 Mediation model

Following Ke et al. (2022), the mediation model is employed to test the mediating role of local governments' environmental attention.

$$\text{Atten}_{it} = \delta_0 + \delta_1 \text{Ed}_{it} + \alpha \text{Control}_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (9)$$

$$\text{Poll}_{it} = \theta_0 + \theta_1 \text{Ed}_{it} + \theta_2 \text{Atten}_{it} + \alpha \text{Control}_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (10)$$

where Atten represents local governments' environmental attention, which is a mediation variable. Equations (7), (9), and (10) constitute the mediation model. The process of the mediating effect test is as follows: (1) If the coefficients β_1 , δ_1 and θ_2 are significant, the mediating effect is established, and there is no need to use Bootstrap or Sobel method to test again, and the coefficient θ_1 is significant, it will be the incomplete mediating effect. If the coefficient θ_1 is not significant, it will be complete mediating effect. (2) If the coefficient β_1 is significant, and either the coefficient δ_1 or θ_2 is not significant, the Bootstrap method or Sobel method should be used to test the coefficient, and one of the coefficients is insignificant. If the result is not significant, the mediating effect does not exist. If the result is significant, the mediating effect exists. If the coefficient θ_1 is not significant, it will be incomplete mediating effect. If the coefficient θ_1 is significant, it will be complete mediating effect. In addition, the coefficient β_1 measures the total effect of ED on environmental pollution, the coefficient θ_1 measures the direct effect of ED on environmental pollution, the coefficient $\delta_1 * \theta_2$ measures the mediating effect of ED on environmental pollution, and the coefficient $(\delta_1 * \theta_2 / \beta_1)$ measures the proportion of the mediating effect.

3.2 Variables

3.2.1 Dependent variable

Environmental pollution (Poll). As ED is measured with RCS implementation in a region, and RCS mainly aims to control water ecological pollution, this study uses the total amount of industrial wastewater discharge to represent environmental pollution, which is recorded as Poll(Water). In order to increase the reliability of the findings in this paper, environmental pollution index is synthesized from wastewater discharge, exhaust gas discharge, and solid waste discharge with the entropy method, and is regressed again after replacing the original explanatory variables of environmental pollution in the robustness test. Among them, environmental pollution index is synthesized from industrial wastewater emissions, sulfur dioxide emissions, and smoke and dust emissions, and it is recorded as Poll(Index).

3.2.2 Independent variable

Environmental decentralization (Ed). Following Li and Wang (2020) and She et al. (2019), the dummy variable of RCS implementation is used to represent ED at the city level. In this paper, the data about the years of implementing the RCS policy in sample cities were obtained from multiple sources, including the legal database of Peking University (pkulaw, <http://www.pkulaw.cn/>), law-star (<http://law1.law-star.com/>), China National Knowledge Infrastructure (CNKI, <https://www.cnki.net/>) and Baidu and cross-validated the measurements as follows: first, by searching the years when each city started implementing the RCS and the corresponding release of official documents. Second, the information was obtained from the official RCS-related documents in the local laws and regulations chapter of pkulaw and law-star. Third, we searched all the news reports and existing literature on RCS in CNKI, extracted the time and corresponding documents of the RCS in each city of the Yangtze River Economic Belt, and finally compared these information with the information obtained previously.

3.2.3 Mediating variable

Local governments' environmental attention (Atten). Many methods can be adopted to measure attention, but the most common and widely used method is text analysis, which combines qualitative and quantitative research. Specifically, the text analysis first requires selection of keywords closely related to the research topics, and then analyzes the studied text and counts the number of times the keywords are used in the text to get the government's attention data. Given that the report on the work of the government is a programmatic policy document for summarizing and planning the governments' work, it can intuitively reflect decision-makers' attention to environmental issues and the distribution of their attention over a period of time. Therefore, the frequency of words related to environmental pollution in local governments' work reports can describe the intensity and changing trend of local government attention. Following Bao and Liu (2022), this paper measures local governments' environmental attention by the frequency of relevant keywords in the government annual reports. In order to more carefully portray the differences in environmental attention among local governments, this paper expands the keywords and selects 23 keywords such as ecology, ecological environment, ecological civilization, and so on.

Finally, this paper measures the local governments' environmental attention with the government annual reports of 108 cities in the Yangtze River Economic Belt from 2003 to 2018. These reports can be accessed from local government website. Due to the missing government work reports of individual cities in some years, the mean filling method was used to complete the data.

3.2.4 Control variables

The following factors are introduced as control variables:

(1) Industrial upgrading (Ind): Following the method of Li (2018), the ratio of the added value of tertiary industry to the added value of secondary sectors was used to characterize industrial structure upgrading, the industrial structure rationalization index was used to represent the rationalization of industrial structure. The calculation formula is as follows:

$$Sr = \sum_{i=1}^n \frac{Y_i}{Y} \left| \frac{Y_i/L_i}{Y/L} - 1 \right| \quad (i \in \{1, 2, 3\}, n = 3) \quad (11)$$

where Sr represents the reciprocal of the structural deviation index. The larger it is, the farther the economy deviates from the equilibrium state and the more irrational the industrial structure. The subscripts i and n denote sector and the number of sector, respectively. Y_i and L_i denote the GDP and labor of sector i , respectively. Finally, the industrial upgrading index was synthesized of two indexes using entropy method;

(2) Technological innovation (Rd): measured with the proportion of the number of scientific research employees to the number of total employees;

(3) Foreign direct investment (Fdi): measured with the proportion of foreign direct investment to GDP;

(4) Urbanization ($Urban$): measured with the proportion of the urbanized population to the total population.

3.2.5 Grouping variable

Fiscal decentralization (Fd). According to Li et al. (2022), this paper selects fiscal revenue decentralization to measure the degree of fiscal decentralization in cities. The calculation formula is as follows:

$$Fd = \frac{Pfr_{city}}{Pfr_{city} + Pfr_{province} + Pfr_{country}} \quad (12)$$

where Fd represents the degree of fiscal decentralization. Pfr_{city} , $Pfr_{province}$, and $Pfr_{country}$ represent fiscal revenue per capita at the city, province, and country levels, respectively. Finally, when the mean of fiscal decentralization of city i is less than the mean of all samples during the sample period, $Group(Fd) = 0$, otherwise it is 1.

3.3 Data

This paper uses the panel data of 108 cities in the Yangtze River Economic Belt from 2003 to 2018. Data sources are as follows: (1) Data on environmental pollution, industrial upgrading, technological innovation, foreign direct investment, and urbanization were

acquired from *China City Statistical Yearbook*, *China Environmental Yearbook*, *China Environmental Statistical Yearbook*, *Provincial Statistical Yearbook*, and *Municipal Statistical Yearbook*. (2) Data on fiscal decentralization was obtained from *China Statistical Yearbook* and *China City Statistical Yearbook*. The above yearbooks were obtained from the China Socio-economic Data Platform (<http://data.cnki.net>). The data sources for the remaining indicators are not repeated. Finally, the descriptive statistics of the variables are shown in Table 1.

4 Empirical analysis

4.1 Baseline results

Table 2 shows the results of the empirical tests on the effect of ED on environmental pollution in the Yangtze River Economic Belt, where Columns (1) and (2) test the effect of ED on environmental pollution in the current period before and after control variables are added, and Columns (3)~(5) test the effect of ED on environmental pollution after 1–3 lag phases. It is not hard to find that the coefficient of the effect of ED on environmental pollution in the current period is negative but insignificant, regardless of whether control variables are added or not, indicating that ED policy produces no immediate effect. Further analysis reveals that the coefficients of the effects of ED on environmental pollution after 1–3 lag phases are all significantly negative, confirming that ED exerts a lagged effect on reducing environmental pollution. In addition, the absolute value of the coefficients of ED variables in Columns (2)~(5) is more significant, indicating that the reducing effect of ED on environmental pollution increases with time. These findings are basically consistent with Zhang and Li (2022). They argue that the ED inhibited green technology innovation in the short term due to the government's shortsighted behavior, whereas ED accelerates green technology innovation in the long run by improving efficiency on environmental management with increasing environmental constraints. As mentioned above, this paper also supports that ED is more effective in fighting pollution by virtue in virtue of its inherent advantages (Falleth & Hovik, 2009; Garcia, 2007; Oates, 2001). Nevertheless, ED is influenced by local fiscal pressure and corruption (Hao et al., 2021; Li et al., 2021a, 2021b). Under the RCS, local governments have pressure and motivation for water pollution control. Meanwhile, the collaboration among various departments within local

Table 1 Variable summary statistics

Variable	Definition	N	Mean	St	Min	Max
Poll(Water)	Environment pollution(water pollution)	1.728	0.842	1.152	0.006	8.570
Ed	Environmental decentralization(ED)	1.728	0.259	0.438	0.000	1.000
Atten	Local governments' environmental attention	1.728	0.370	0.204	0.020	1.430
Ind	Industrial upgrading	1.728	0.037	0.045	0.004	0.923
Rd	Technological innovation	1.728	0.015	0.010	0.001	0.078
Fdi	Foreign direct investment	1.728	0.021	0.024	0.000	0.463
Urban	Rate of urbanization	1.728	0.483	0.141	0.161	0.896
Poll(Index)	Environment pollution(comprehensive index)	1.728	0.064	0.075	0.001	0.696
Group(Fd)	Grouping variable (fiscal decentralization)	1.728	0.426	0.495	0.000	1.000

Table 2 Baseline results of ED on environmental pollution

Model	(1)	(2)	(3)	(4)	(5)
Variable	<i>Poll(Water)</i>				
<i>Ed</i>	-0.07 (-1.438)	-0.02 (-0.414)			
<i>L.Ed</i>			-0.092* (-1.796)		
<i>L2.Ed</i>				-0.144*** (-2.668)	
<i>L3.Ed</i>					-0.216*** (-3.822)
<i>Ind</i>		-0.831*** (-4.748)	-0.763*** (-4.263)	-0.734*** (-4.051)	-0.624*** (-3.532)
<i>Rd</i>		3.636 (1.102)	3.084 (0.93)	1.908 (0.598)	1.438 (0.461)
<i>Fdi</i>		0.201 (-0.235)	0.083 (0.094)	0.256 (0.308)	0.399 (0.505)
<i>Urban</i>		1.582*** (3.102)	1.902*** (3.403)	2.370*** (3.782)	2.432*** (3.836)
_cons	4.561*** (23.702)	3.576*** (7.633)	3.167*** (6.454)	2.776*** (5.352)	2.590*** (4.829)
Time-FE	Yes	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes	Yes
Observations	1728	1728	1620	1512	1404
R^2	0.865	0.868	0.869	0.87	0.877

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

governments has been optimized by raising the priority of environmental governance. In the long run, with the improvement of the RCS, local government pay more attention to the environment and take the initiative to circumvent inaction in environmental governance, which improves regional environmental quality.

4.2 Robustness check

4.2.1 Parallel trend test

As parallel trend assumption must be met when the time-varying DID model is adopted, this paper estimates Eq. (8), and Fig. 2 shows the dynamic impact of ED on environmental pollution. As shown in Fig. 2: First, before the ED system was implemented, the coefficient of ED variables was not significantly different from 0; second, according to the results of baseline regression, the effect of ED on environmental pollution in the current period is statistically insignificant. However, according to the dynamic effect, after ED was implemented for 4 years, the coefficients of ED variables was significantly negative; third, the whole dynamic process found that the significance gradually increases with the higher absolute value of the coefficients of ED variables. This indicates that: (1) parallel trend

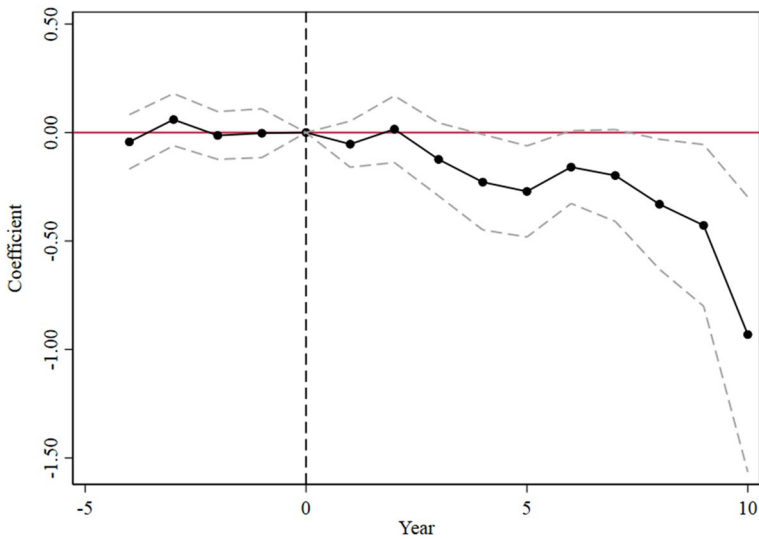


Fig. 2 Estimation results of parallel trend test

assumption is verified, (2) ED helps reduce environmental pollution, but it has a lagged effect, and (3) ED exerts a greater improving effect on the environment with time.

4.2.2 Counterfactual test

Following the method of Zhou et al. (2021), this paper changes the implementation time of the RCS in various places for the time counterfactual test. Specifically, this paper advances the implementation time of RCS by 1 year and 2 years, respectively, to empirically study the effect of ED on environmental pollution, and the time counterfactual test is passed if the coefficients of ED variables are not significant. The results are shown in Table 3. The empirical result of Columns (1)~(2) of Table 3 further verifies that improving environmental pollution is not caused by other factors, but by the result of ED implementation, i.e., RCS policy.

4.2.3 PSM-DID test

The coefficient estimation for ED may be disturbed by self-selection bias, i.e., cities that implemented the RCS policy earlier paid more attention to the environment and adopted stricter environmental regulation policies. Therefore, the matching method was used to eliminate this bias as much as possible (Mardones & Herreros, 2022), and this paper has re-estimated the coefficients of ED variables with the processed data. The matching variables are the control variables. Table 4 presents the results of matching equilibrium test. It is found that the biases of control variables between the treated and control group are less than 10% and not statistically significant after data processing, which proves that matching is reasonable.

Table 5 shows the estimation results of PSM-DID test. According to Table 5, although the absolute values of coefficients of ED are slightly less than the baseline

Table 3 Estimation results of counterfactual test

Model	(1)	(2)
Variable	<i>Poll(Water)</i>	
<i>F.Ed</i>	0.005 (0.105)	
<i>F2.Ed</i>		0.003 (0.053)
Control	Yes	Yes
Time-FE	Yes	Yes
City-FE	Yes	Yes
_cons	3.777*** (7.818)	4.149*** (8.431)
Observations	1620	1512
R^2	0.878	0.892

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

Table 4 Results of matching equilibrium test

Variable		Mean		Bias (%)	t-test	
		Treated	Control		t	$p > t $
<i>Ind</i>	Unmatched	0.23891	0.20085	16.9	3.45	0.001
	Matched	0.23501	0.25684	-9.7	-1.18	0.239
<i>Rd</i>	Unmatched	0.01446	0.01454	-0.7	-0.14	0.887
	Matched	0.01439	0.01489	-4.8	-0.69	0.490
<i>Fdi</i>	Unmatched	0.01670	0.02252	-25.6	-4.52	0.000
	Matched	0.01713	0.01769	-2.5	-0.44	0.661
<i>Urban</i>	Unmatched	0.56866	0.45373	91	15.84	0.000
	Matched	0.56154	0.56758	-4.8	-0.74	0.462

regression, their magnitude and significance did not change. It is supported that ED can improve pollution control in the long run.

4.2.4 Concurrent events

The research period in this study is from 2003 to 2018, during which five development concepts were implemented (2015) apart from the RCS policy. Thus, to exclude the impact of five development concepts on the empirical results, this paper draws on the method of Ge et al. (2022) and introduces the interaction term (Did) of the grouping dummy variable whether “five development concepts” are implemented and the implementation time dummy variable, to further test the impact of ED on environmental pollution through controlling the implementation of the policy. See the result in Columns (1)~(4) of Table 6. The coefficients and significance of ED variable were consistent with the baseline regression, which shows that ED can indeed reduce environmental pollution in the long term.

Table 5 Estimation results of PSM-DID test

Model	(1)	(2)	(3)	(4)
Variable	<i>Poll(Water)</i>			
<i>Ed</i>	-0.034 (-0.709)			
<i>L.Ed</i>		-0.096* (-1.842)		
<i>L2.Ed</i>			-0.131** (-2.353)	
<i>L3.Ed</i>				-0.187*** (-3.220)
Control	Yes	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes
_cons	3.841*** (8.087)	3.441*** (6.930)	3.079*** (5.858)	2.954*** (5.439)
Observations	1697	1589	1482	1375
R ²	0.872	0.873	0.874	0.881

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

Table 6 Estimation results of concurrent events

Model	(1)	(2)	(3)	(4)
Variable	<i>Poll(Water)</i>			
<i>Ed</i>	-0.02 (-0.414)			
<i>L.Ed</i>		-0.092* (-1.796)		
<i>L2.Ed</i>			-0.144*** (-2.668)	
<i>L3.Ed</i>				-0.216*** (-3.822)
<i>Did</i>	-0.830*** (-5.955)	-0.778*** (-5.725)	-0.920*** (-6.469)	-0.838*** (-6.642)
Control	Yes	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes
_cons	3.576*** (7.633)	3.167*** (6.454)	2.776*** (5.352)	2.590*** (4.829)
Observations	1728	1620	1512	1404
R ²	0.868	0.869	0.87	0.877

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

4.2.5 Replacing the explanatory variables

In order to further enhance the credibility of the conclusions, this paper replaces water pollution with a composite index for robustness test, and the result is shown in Columns (1)~(5) of Table 7. It can be found that the coefficients of the impact of ED on pollution composite index are not significant in the current period, but the coefficients of the impact of ED on pollution index are significantly negative after 2~3 lag phases. With the longer lagging periods, the absolute value of the coefficient of ED variable and the significance gradually increase. This shows that ED significantly reduces environmental pollution with a lagged effect, and the environmental improving effect of ED intensifies over time, which verifies the robustness of the study.

4.2.6 Robustness test excluding the interference of the full implementation of the RCS

Since the opinion on comprehensively promoting the RCS issued in December 2016 proposed to fully implement the RCS in all regions, RCS has changed from a strategic imitation among local governments to a top-down mandatory constraint, which may cause interference in two aspects: First, it is hard to avoid local selective implementation behavior, which impacts the average policy effect; second, in 2017, all 108 cities in the Yangtze River Economic Belt have established the RCS, so there were no control group without implementing the RCS after 2017. Thus, this paper removes the data of the RCS after 2017 for robustness test, and the results are shown in Table 8. The coefficients of ED variables in Columns (3)~(5) of Table 8 are all significantly negative, and the absolute value of the coefficients of ED variables increases with the longer lag phases of ED variables, indicating that the improving effect of ED on environmental pollution is still persistent after the interference of the no control group is excluded, and this improving effect also increases

Table 7 Estimation results of replacing the explanatory variables

Model	(1)	(2)	(3)	(4)
Variable	<i>Poll(Index)</i>			
<i>Ed</i>	0.004 (1.118)			
<i>L.Ed</i>		-0.004 (-1.223)		
<i>L2.Ed</i>			-0.011*** (-2.957)	
<i>L3.Ed</i>				-0.017*** (-4.338)
Control	Yes	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes
_cons	0.226*** (6.011)	0.201*** (4.979)	0.166*** (4.025)	0.144*** (3.371)
<i>N</i>	1728	1620	1512	1404
<i>R-sq</i>	0.861	0.859	0.859	0.862

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

Table 8 Estimation results of excluding the interference of the full implementation of the RCS

Model	(1)	(2)	(3)	(4)
Variable	<i>Poll(Water)</i>			
<i>Ed</i>	-0.066 (-1.238)			
<i>L.Ed</i>		-0.127** (-2.014)		
<i>L2.Ed</i>			-0.132* (-1.759)	
<i>L3.Ed</i>				-0.167** (-2.230)
Control	Yes	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes
_cons	4.066*** (7.903)	3.527*** (6.433)	3.060*** (5.114)	2.967*** (4.665)
Observations	1512	1404	1296	1188
R^2	0.892	0.892	0.893	0.898

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

with time. This is consistent with the previous findings and further verifies the robustness of the conclusions in this study.

4.3 Mediating effect test

This paper uses the causal steps approach for the mediating effect test to further study the mediating effect of ED on local governments' attention to environmental pollution. Based on the above analysis, RCS exerts a lagged effect on environmental pollution. Moreover, the government annual reports summarize the achievements in the last year, which reduces the measurement accuracy of environmental attention of the year issuing reports. Thus, this paper treats the coefficients of ED variables as a lag phase in Columns (1)~(3) of Table 9. See the result in Table 9. Column (1) tests the impact of ED on environmental pollution. It is found that the coefficients of ED variables are all significantly negative, indicating that ED can reduce environmental pollution, i.e., the RCS can effectively reduce water pollution. Column (2) tests the effect of ED on local governments' environmental attention. This paper finds that all the coefficients of the impact of ED on local governments' environmental attention are significantly positive, indicating that ED is conducive to increasing the local governments' environmental attention, i.e., ED can promote local governments' attention to environmental protection. Column (3) further studies the effect of ED and environmental attention on environmental pollution. It is found that the coefficient of environmental attention variable is negative at the significance level of 5%, indicating that more local governments' environmental attention can reduce environmental pollution, while the absolute value of the coefficient of ED decreases compared to the first-stage regression, finally confirming that ED significantly reduces environmental pollution by increasing local governments' environmental attention. Further analysis reveals that the direct effect of ED on environmental pollution in Columns (1)~(3) is -0.083 and the mediating effect

Table 9 Estimation results of mediating effect

Model	(1)	(2)	(3)
Variable	<i>Poll(Water)</i>	<i>Atten</i>	<i>Poll(Water)</i>
<i>L.Ed</i>	-0.092* (-1.796)	0.039*** (2.890)	-0.084* (-1.659)
<i>Atten</i>			-0.216** (-2.053)
Control	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes
City-FE	Yes	Yes	Yes
_cons	3.167*** (6.454)	-0.039 (-0.300)	3.158*** (6.349)
Observations	1620	1620	1620
R^2	0.869	0.665	0.869

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

of environmental attention is -0.009 , with the mediating effect accounting for 9.78% of the total utility. Feng et al. (2020) also suggested that ED gives more free space to the local governments, which enhances its enthusiasm to improve the environment. As mentioned above, ED can encourage local governments to pay more attention to the environment. Specifically, under the RCS policy, the heads of local governments, rather than the local environmental bodies, are directly accredited with responsibility for environmental management, which highlights the priority of environmental issues. This measure contributes to optimizing the collaboration among various departments within local governments, and also reducing the shirking of responsibility. More than that the performance of local officials for environmental governance is included in the promotion system. In a word, local governments have pressure and motivation for environmental governance, which encourages local governments to pay more attention to environment (Li et al., 2022). Meanwhile, enterprises and the public are also involved in environmental management, playing a positive role in the control of pollutants.

4.4 Heterogeneity test

It has been confirmed that ED exerts a lagged effect on reducing environmental pollution at the city level in the Yangtze River Economic Belt, and the effect increases over time. Considering differences in the degree of fiscal decentralization among cities, this paper further explores the heterogeneous effects of ED on environmental pollution. As mentioned before, the sample cities were divided into cities with low and high fiscal decentralization and grouped for empirical tests. Table 10 presents the estimated results of heterogeneity test by fiscal decentralization, where Columns (1) and (5) test the effect of ED on environmental pollution in the current period, and Columns (2)~(4) and (6)~(8) test the effect of ED on environmental pollution after 1–3 lag phases. Comparing Column (1) with Column (2), it is found that ED exerts an immediate effect on environmental pollution. The effect of ED on environmental pollution is significantly negative in cities with high fiscal decentralization, but it is significantly positive in cities with low fiscal decentralization. Li et al. (2021a, 2021b) supported that the disincentive effect of ED on environmental pollution gradually increases with the decreasing fiscal pressure. In terms of our study, the reason

Table 10 Estimated results of heterogeneity test by fiscal decentralization

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Group	Low fiscal decentralization				High fiscal decentralization			
Variable	<i>Poll(Water)</i>							
<i>Ed</i>	0.114*** (3.545)				-0.160* (-1.756)			
<i>L.Ed</i>		0.088*** (2.843)				-0.238** (-2.473)		
<i>L2.Ed</i>			0.064** (2.083)				-0.269*** (-2.727)	
<i>L3.Ed</i>				0.012 (0.415)				-0.355*** (-3.509)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	1.085*** (12.532)	1.108*** (11.939)	1.150*** (11.093)	1.132*** (10.855)	3.668*** (8.511)	3.466*** (8.357)	3.545*** (8.81)	3.527*** (9.055)
<i>N</i>	992	930	868	806	736	690	644	598
<i>R-sq</i>	0.735	0.737	0.739	0.751	0.866	0.866	0.868	0.875

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $t(z)$ statistics in parentheses

for this may be multifaceted. Higher revenue decentralization allows local governments to fund environmental management more, implying the information and cost advantage of ED can be better played for improving regional environmental quality (He, 2015; Liu & Zhang, 2013; Wang et al., 2022a, 2022b). On the contrary, there is the double-edged effect of fiscal decentralization on environmental pollution. Low fiscal revenue decentralization intensifies local governments' dependence on investment and reduces concern for regional environmental governance (Li & Ding, 2022; Qi & Yu, 2023), and thus ED becomes the booster of environmental pollution. Notably, the positive effect of ED on pollutants control increases over time in cities with high fiscal decentralization, and the negative effect decreases over time in other cities. This indicates that with the improvement of the RCS policy, ED can effectively restrain inaction in environmental governance, promote environmental management concerns, and improve the efficiency of pollutant control.

5 Conclusions and policy implications

Environmental pollution is related to the sustainable development of China's economy. Reasonable and efficient allocation of rights and responsibilities for environmental management at the central and local levels holds the key to environmental improvement. In China, however, whether decentralized systems for environmental management should be established has been disputed for a long period. Based on the attention theory, this paper takes ED, local governments' environmental attention, and environmental pollution in a unified analytical framework for the first time and systematically explains the theoretical mechanism by which ED restrains environmental pollution. After that, it clarifies the

relationship between the ED and RCS policy and presents that the RCS is a decentralized policy. Exploiting the cross-city, cross-year variation in the timing of the establishment of RCS, it also empirically tests the effect of ED on pollution control at the city level in the Yangtze River Economic Belt and the mediating effect of local governments' environmental attention with the DID and PSM-DID methods for mitigating the endogeneity of the coefficient estimates. Lastly, this paper further explores the heterogeneous effects of ED on environmental pollution among cities with variable degrees of fiscal decentralization. The main conclusions are as follows:

First, at the city level in the Yangtze River Economic Belt, ED plays a lagging positive role in reducing environmental pollution and this blessing increases with time, which is further verified by the robustness tests from various dimensions such as PSM-DID and other methods. In the context of the RCS, ED can effectively leverage information advantages, cost advantages, and "national laboratory" effects and avoid bottom-up competition to improve environmental quality. Second, in terms of heterogeneity, the effect of ED on pollutants control is significant in the current period but its direction is different among different cities. It is positive and increases with time in cities with a high degree of fiscal decentralization, but it is negative and decreases with time in other cities, which implies that the RCS, an ED policy, still suffers from distorted incentives. Of course, with the improvement of the RCS, the inaction and shirking of responsibility will be effectively curbed. Lastly, the mediating effect of environmental attention is verified and is an incomplete mediating effect, i.e., ED can curb environmental pollution by improving the local governments' environmental attention. The RCS can encourage local governments to pay more attention to the environment and motivate businesses and the public to participate in environmental protection.

The findings in the study enlighten us from the following aspects:

First, more freedom should be given to local governments in environmental management. The empirical study indicates that at least at the city level in the Yangtze River Economic Belt, ED can lead to better environmental benefits. Therefore, considering that local governments have a better understanding of the situation of local ecological environment and pollution discharge by enterprises (such as the types of pollutants, the distribution of pollution sources, and the amount of pollution emitted), local governments should be provided with sufficient autonomy in law enforcement in their jurisdictions to achieve more effective regulation. In order to promote the rational allocation of funds and avoid interference with enterprise production and the waste of resources, the higher governments should provide lower-level governments with sufficient autonomy in the use of personnel and funds in environmental protection departments. In addition, local governments need to be given a greater degree of freedom to develop environmental regulatory and subsidy policies, which will help accelerate enterprises' green innovation and guide residents to increase green consumption pointedly.

Second, the central government should strengthen the assessment and supervision of local environmental performance. This paper empirically reveals that the emission reduction effect of ED is delayed, which implies that environmental protection policies are not implemented in time. However, with the improvement of the RCS, local environmental performance has gradually improved. Meanwhile, government attention plays an important role in promoting local environmental protection. Therefore, in order to avoid inaction and evasion of responsibility of local governments, the central government should stick to the RCS. While delegating the power of law enforcement, supervision and monitoring of local environmental protection should be strengthened. The ultimate goal is to achieve authority with corresponding responsibility, rather than traditional decentralization.

Thirdly, differentiated ED policies should be formulated. The empirical results show that in cities with low fiscal decentralization, environmental decentralization becomes the catalyst of environmental pollution. Therefore, to ease the financial pressure on local governments, the central government needs to support these cities with money and staff for environmental protection, which helps promote high-quality economic development and reduce environmental pollution in China.

In conclusion, this paper provides a new perspective for understanding the emissions reduction effect of ED and adds new empirical evidence. However, there are still some limitations worthy of follow-up research. First, microdata such as industrial enterprise databases could be used to conduct empirical studies, ensuring that the findings are universal. Second, the mechanism by which ED affects environmental pollution can be further explored. Lastly, the issue of environmental monitoring data revision by local governments also deserves to be explored and analyzed.

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Data availability The datasets generated or analyzed during this study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Consent for publication Not applicable.

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