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Original Research

Incentive or Disincentive? Impact of Environmental Inputs on the Efficiency of Ecological Management – A Meta-Analysis of Evidence from China

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Abstract

The efficiency of eco-environmental governance can be influenced by a variety of factors, and different factors have different effects on eco-environmental governance efficiency. This study attempts to investigate the impact of environmental protection input on the efficiency of ecological environmental governance in China. By using Meta-analysis, the effects of environmental protection input on eco-environmental governance efficiency were selected under 35 independent samples studying eco-environmental governance efficiency in China from 2010 to 2022. Meta-binary analysis and regression analysis were also used to explore the moderating effects of potential moderating variables on the relationship between environmental protection input and eco-environmental governance efficiency. The empirical results demonstrate that: (1) environmental protection inputs have a significant positive effect on the efficiency of eco-environmental governance in China in all dimensions. (2) The relationship between environmental protection input and eco-environmental governance efficiency is moderated by measurement scope, measurement dimension, technological innovation, and environmental regulation. Based on the empirical findings, this study further proposes policy recommendations to improve the efficiency of China's eco-environmental governance, including increasing environmental protection investment, playing a leading role in the government, addressing regional economic differences, increasing scientific and technological innovation, and improving the environmental regulation system.

Keywords: environmental input, ecological environment, governance efficiency, Meta-analysis, China

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Introduction

Since 1978, China has established the path of market-oriented mechanism development through economic system reform. China's economy began to be changed from an agricultural economy to an industrial economy. The rapid development of industry has contributed to the rapid growth of China's economy and has also been a major force in raising incomes. While China has experienced a boom in economic growth, it has grown into the world's largest emitter of greenhouse gases and the most polluting city in the world [1]. Specifically, they state that China accounts for 17 of the 25 most polluted cities in the world. In order to improve environmental pollution, the Chinese government has gradually taken a series of environmental management measures and decisions, covering various aspects of environmental management such as air, water, and natural resources. Among these measures, environmental investment is only one of the most widely applied measures. According to public data from the National Bureau of Statistics and the National Development and Reform Commission, China's total financial investment in environmental protection has reached 3 trillion yuan, with an average annual growth rate of 7.47% [2]. At the same time, the Chinese government has introduced corresponding incentives for foreign green investment, including lower corporate taxes for foreign-invested companies, as well as investment in environmental protection, increased asset investment allowances, and tax credits [3]. This begs the question: does environmental investment play a critical role in the management of China's ecological environment? To address this question, a large number of studies have empirically analyzed how environmental inputs affect the efficiency of eco-environmental governance. However, the empirical analysis of this issue has not formed a unified conclusion, but rather a large divergence [4]. Huang et al. argue that government environmental governance investment and eco-environmental governance efficiency show an inverted "U" shape and do not have a significant effect [5]. However, Liu et al. pointed out that government environmental protection investment has a significant effect on ecological pollution management and can improve ecological environmental governance efficiency [6].

At present, there is no large-scale meta-analysis to examine the correlation between environmental protection input and eco-environmental governance efficiency and to explore in depth the reasons for the inconsistent findings of existing studies. Based on the current status of existing research, the question studied in this paper is what kind of relationship between environmental protection input and eco-environmental governance efficiency? What are the factors that affect this relationship? To address these questions, this study combines existing empirical studies and adopts a meta-analysis method based on the Chinese context to systematically evaluate the effects of different environmental protection inputs on eco-environmental governance efficiency, analyze whether there is heterogeneity in the effects of measurement dimensions, measurement scope, technological innovation, and environmental regulation, and provide a theoretical basis and policy reference for environmental protection inputs to enhance eco-environmental governance efficiency.

The research idea of this paper is to first review and sort out the relevant literature and form the main framework of the study on this basis. Secondly, the effective value extraction and heterogeneity analysis are conducted in strict accordance with the prescribed procedure of Meta-analysis and CMA3.0 software. Finally, a moderating effect analysis and regression analysis were conducted to test the hypotheses on the differences of different types of environmental protection input on the efficiency of ecological and environmental management.

Theoretical Review and Research Hypothesis

Main Effect: Environmental Protection Input and their Dimensions and Eco-Environmental Governance Efficiency

Environmental Protection Input and Ecosystem Management Efficiency

Environmental protection input, as an important element of the ecological and environmental governance mechanism, has become an important condition to measure the efficiency of ecological and environmental governance. For environmental protection input, most scholars regard it as an investment or cost to improve the quality of the ecological environment. Therefore, some scholars have divided the concept of environmental protection input into two types: the cost theory and the investment theory [7]. According to the "cost theory", environmental protection input is the cost paid by the state to control pollution, including pollution prevention, damage, treatment, and management costs [8]. The "investment theory" believes that the main body of environmental protection input is not only the state, but also includes enterprises, and the main body of investment and the main body of benefit is not the same, and the benefits are not only in the resources and environment but also in the economic and technical aspects. In this regard, scholars have confirmed the hypothesis of the "investment theory" of environmental protection investment, and also included the "cost theory" of pollution prevention, damage, governance, and management costs [9]. In addition, some researchers have classified environmental protection input according to the scope and target of the input, starting from the content of the input. In terms of input objects, all funds used for environmental protection in Europe and the United States are considered environmental protection input. In China, environmental protection input includes

various pollution prevention and ecological restoration. In terms of input scope, environmental protection input is not only financial input but also includes human and technical input [10]. In this paper, we consider environmental protection investment as the investment of the state and enterprises to improve the quality of the ecological environment and include human, technology, and industrial structure investment in the study.

For the study of eco-environmental governance efficiency, a lot of literature has been discussed at the enterprise level, and the problems in the process of enterprise environmental management have been examined by assessing the enterprise performance and then proposing corresponding countermeasures [11]. With the formation and development of governance theory, the efficiency of eco-environmental governance has changed from the micro level of enterprises to the macro level of the state and society. Some researchers point out the fact that the central government should take responsibility for environmental governance. The central government, as a supplier of environmental public goods, is able to realize nationwide gains in economies of scale [12]. Therefore, for the government, the efficiency of eco-environmental governance is the impact of the central government or local government in solving eco-environmental problems through the formulation and implementation of environmental policies [13]. Based on the above conceptual definition, this paper defines eco-environmental governance efficiency as the degree to which the government effectively achieves its goals after establishing an eco-environmental governance system and thus solving eco-environmental problems driven by its responsibility for environmental governance.

In terms of the impact of environmental protection input on the efficiency of ecological and environmental management, there is some disagreement among existing studies. Some researchers say that there is a lagging correlation between environmental protection input and eco-environmental governance efficiency, and therefore it has a suppressive effect on environmental pollution and is not conducive to the improvement of eco-environmental governance efficiency [14]. However, more mainstream views believe that environmental protection input has a positive promoting effect on eco-environmental governance efficiency. On the one hand, it can effectively improve environmental quality and promote sustainable economic development [15], on the other hand, it can effectively stimulate the development of the environmental protection industry and lay the foundation for the realization of "carbon peaking" and "carbon neutral" goals, which to a certain extent promotes the improvement of ecological and environmental management efficiency [16]. On the other hand, it can effectively stimulate the development of the environmental protection industry, laying the foundation for the realization of "peak carbon" and "carbon neutral" goals, and to a certain extent promoting the improvement of ecological and environmental management efficiency. Therefore, there is a significant positive relationship between environmental protection investment as the strategic direction of the government's eco-environmental management and eco-environmental management efficiency, i.e., the greater the environmental protection investment, the higher the eco-environmental management efficiency [17]. In summary, this paper proposes the following hypotheses.

H1: There is a significant positive relationship between environmental protection investment and eco-environmental governance efficiency.

Environmental Input Dimensions and Eco-Environmental Governance Efficiency

Current national investment in environmental protection can be summarized in two ways. One is the government's financial investment and the other is the enterprise's investment in environmental protection [18]. Fiscal environmental protection input is mainly governmental, which mainly refers to the part of environmental protection expenditure that the government puts in to achieve governmental environmental protection functions and solve various environmental problems [19]. Although some studies have suggested that financial environmental protection investment has a negative impact on ecological and environmental governance efficiency [20], more studies have shown that financial environmental protection investment can effectively improve ecological and environmental quality and reduce the degree of environmental pollution, thus there is a significant positive relationship between it and ecological and environmental governance efficiency [21, 22]. Enterprise environmental protection investment is the various funds used by enterprises to protect and improve the ecological environment in order to achieve the unity of economic, ecological, and social benefits, and the sources of funds include both local enterprise investment and foreign direct investment [23]. Corporate environmental protection investment, as an important initiative to achieve corporate low-carbon environmental protection goals and an important decision to achieve corporate sustainable development, has a significant positive impact on enhancing the efficiency of ecological and environmental management [24, 25].

In summary, although scholars have conducted a large number of empirical studies on eco-environmental governance efficiency, they have reached different conclusions due to different research methods, variable selection, and measurement factors. However, from a long-term perspective, both financial and corporate environmental investments are conducive to the improvement of eco-environmental management efficiency. Therefore, the following hypotheses are proposed.

H2a: There is a significant positive relationship between financial investment in environmental

protection and eco-environmental management efficiency.

H2b: There is a significant positive correlation between corporate environmental protection investment and eco-environmental management efficiency.

Potential Moderating Variables

Researchers are unable to fully explore the effects of potential moderating variables due to the limitation of the sample space, and therefore inconsistent findings can be formed. The meta-analysis method compensates for this shortcoming and allows a larger sample space to explore the effects of environmental inputs and the effects of potential moderating variables. Regarding the selection of moderating variables in the meta-analysis, different scholars have chosen them in different ways. Some scholars divide the moderating variables into contextual factors and measurement factors [26]. Some scholars also divide the moderating variables into time factors, measurement instruments, performance criteria, and mediating variables [27].

Therefore, this study combines the classification approaches of the above researchers and classifies moderating variables into two major categories, namely measurement factors and mediating factors. Measurement factors include measurement scope and measurement dimension, and mediating factors include STI and environmental regulation.

Measurement Range: Nationwide vs. Regional Range

The range of measurements can lead to different effects of environmental inputs on the efficiency of ecological management. Different sample strata can be a source of heterogeneity. For example, some studies take provinces as individuals and explore the impact of nationwide environmental protection input on the efficiency of eco-environmental management [28, 17]. Some studies take municipalities as individuals and explore the impact of environmental protection input on the efficiency of eco-environmental management at the regional level [29]. There are issues such as resource endowments in environmental protection input nationally and regionally, which result in different impacts on the ecological and environmental governance efficiency developed. In general, environmental protection input on a larger scale has a positive effect on the improvement of eco-environmental governance efficiency. For this reason, this paper proposes the following hypothesis.

H3: The relationship between environmental protection input and eco-environmental governance efficiency is influenced by the scope of measurement, and nationwide environmental protection inputs have a more pronounced effect on the improvement of eco-environmental governance efficiency.

Measurement Dimension: Overall Measurement Dimension vs. Single Measurement Dimension

Currently, scholars divide ecological environmental governance into atmospheric, water, and solid waste treatment aspects [30], and explore the impact of environmental protection inputs on their efficiency from a single dimension, i.e., one of the categories of ecological environmental governance [31], and a multidimensional integrated dimension [32], respectively. Through extensive literature in comparison, this paper finds that the multidimensional consideration of environmental protection input on the efficiency of eco-environmental governance is more significant than that of a single dimension. Accordingly, this paper proposes the following hypothesis.

H4: The relationship between environmental protection input and eco-environmental governance efficiency is influenced by the measurement dimension, and the improvement of eco-environmental governance efficiency is more significant with multi-dimensional environmental protection input.

Science and Technology Innovation: High Innovation Capacity vs. Low Innovation Capacity

On the relationship between environmental protection input and eco-environmental governance efficiency, it is also subject to different conclusions from the influence of relevant mediating variables. Science and technology innovation as a technological input can have a certain influence on the efficiency of eco-environmental governance. Some scholars point out that STI as a mediating variable in the study of environmental protection inputs and eco-environmental governance efficiency will significantly enhance eco-environmental governance efficiency [33]. However, some scholars believe that due to the "rebound effect" of energy consumption, science, and technology innovation may not have a significant impact on the improvement of eco-environmental management efficiency [34]. Based on the research of related scholars, the following hypotheses suggest in this paper.

H5: The relationship between environmental investment and eco-environmental management efficiency will be influenced by science and technology innovation, and the improvement of eco-environmental management efficiency will be more obvious in regions with high science and technology innovation.

Environmental Regulation: High Government Intervention vs. Low Government Intervention

Like scientific and technological innovation, environmental regulation as an important mediating variable has an important role in the study of the relationship between environmental protection input and the efficiency of ecological and environmental management. Environmental regulation means the

sum of all rules that are beneficial to environmental pollution prevention and control and aims to constrain economic agents to reduce pollution [35]. Although some researchers believe that environmental regulation has a suppressive effect on the efficiency of ecological management [33], most researchers believe that environmental regulation as an effective mediating variable will have a positive impact on the improvement of ecological management efficiency [36] [37]. Accordingly, this paper proposes the following hypothesis.

H6: The relationship between environmental input and ecological governance efficiency will be affected by environmental regulation, and the improvement of ecological governance efficiency will be more obvious in regions with high government intervention in environmental input.

Taken together, the resulting research framework model is proposed in this paper (Fig. 1).

Research Design

Research Methods

Meta-analysis is the process of statistically analyzing the results of multiple studies in order to integrate research findings [38]. With the emphasis on the importance of evidence in social science research and the growth in demand for integrative research, meta-analysis has been in a position to gain widespread use in social science research. 2018 Nature magazines commented that "meta-analysis has had an important impact in many scientific fields and has been extremely helpful in establishing evidence-based practice and resolving seemingly contradictory research findings [39]. " Therefore, meta-analysis i.e. makes up for the inability of literature review to comprehensively and systematically sort out empirical studies and ensures the objectivity and scientifical of literature sorting [40]. Meta-analysis has a corresponding standard process, including literature search, exclusion principles, information coding, and data analysis. Each step should follow the corresponding principles. The main reasons for choosing Meta-analysis in this paper are: First, there are a large number of empirical studies on the relationship between environmental protection input and ecological management efficiency, which meet the requirements of Meta-analysis for literature quantity. Secondly, there are differences in the conclusions reached in the empirical studies on the relationship between the two, which meet the requirements of Meta-analysis for the research conclusions.

Literature Search and Selection

This study followed the META-Net protocol as elaborated by Stanley et al. in terms of a literature search [41]. A preliminary search was conducted using a combination of keywords, including "Environmental protection investment", "Fiscal input into environmental protection", "Enterprise Environmental Protection Input", "Efficiency of environmental governance", and "Foreign direct investment". Searches were conducted using the English search engines EconLit, JSTOR, EBSCO, Google Scholar, RePEc, SSRN, Social Science Citation Index (SSCI), and Scopus. We also searched for Chinese search engines CNKI, CQVIP, Wanfang Data, and Scientific Papers Online. The initial search yielded 1131 studies.

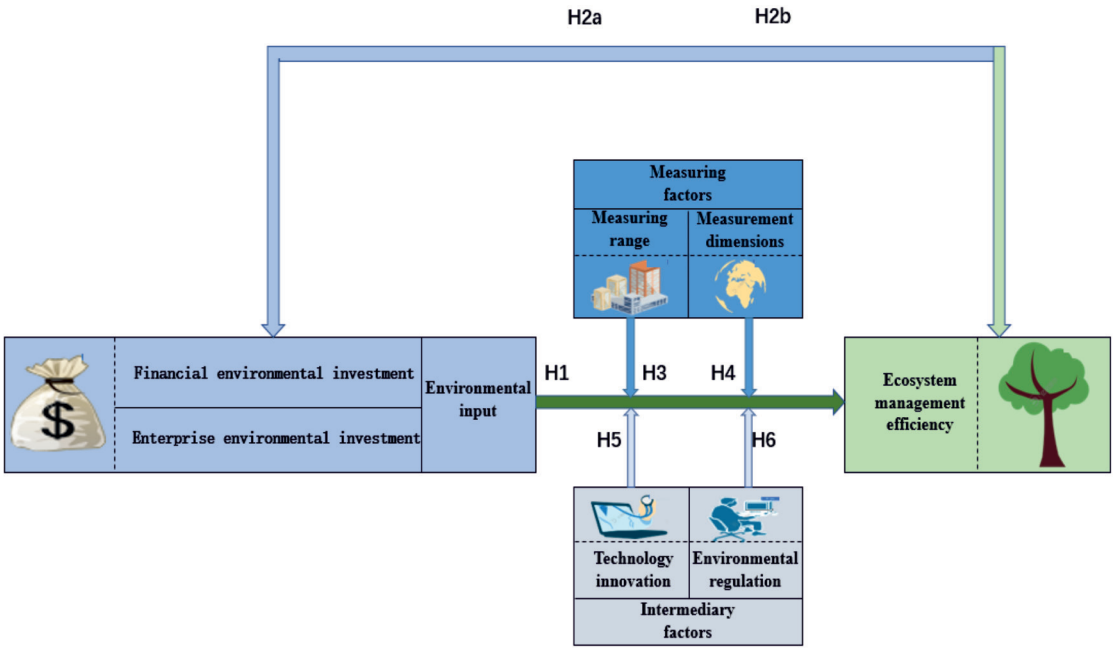

Fig. 1. Research model.

According to the rules of Meta-analysis on literature selection, this study conducted literature screening according to the following criteria: (1) the selected literature needs to be a study on the impact of ecological and environmental management efficiency; (2) the literature needs to be an empirical study and the sample size (or can be inferred based on time) and correlation coefficient (or other convertible indicators) are reported in the text; (3) each study sample needs to be independent, and the literature of the same sample using the earliest published literature for the study; (4) three effect values need to exist for the independent and dependent variables.

In addition, to ensure the validity of the Meta-analysis, a quality assessment of the screened literature is required. In this paper, the following rules were established for assessing the quality of the literature concerning the practice of Dong et al. [42]: (1) The score was assigned according to the publication level of the literature. A score of 0.5 is assigned for publication in general journals, 1 point should be calculated for "Research Center for Chinese Science Evaluation"(RCCSE) journals, and 2 points should be assigned for source studies of "Social Sciences Citation Index"(SSCI) journals and "Chinese Social Sciences Citation Index"(CSSCI) journals. The value of the dissertations is consistent with that of general journals. (2) Points are assigned based on the experience of the author of the literature. Researchers who have published only one article on the same topic are assigned 1 point, and those who have published multiple articles on the same topic are assigned 2 points. (3) Scores were assigned based on whether the literature was tested with panel data. Literature without panel data testing is assigned 0.5 points, and literature with panel data testing is assigned 2 points. (4) Scores were assigned based on the time range of the panel data. A score of 0.5 was assigned if the panel data did not contain statistics from the past ten years, and a score of 2 was assigned if the panel data had statistics from the past ten years. The total score for each study ranged from 0 to 8, with higher scores indicating better quality of the selected literature. Those studies with a score below 2 were excluded.

According to the above literature screening criteria and quality assessment criteria, 35 standard papers were obtained, including 24 papers in Chinese and 11 papers in English. (See Fig. 2 for the literature screening process) Simulation results by Fang et al. [43] showed

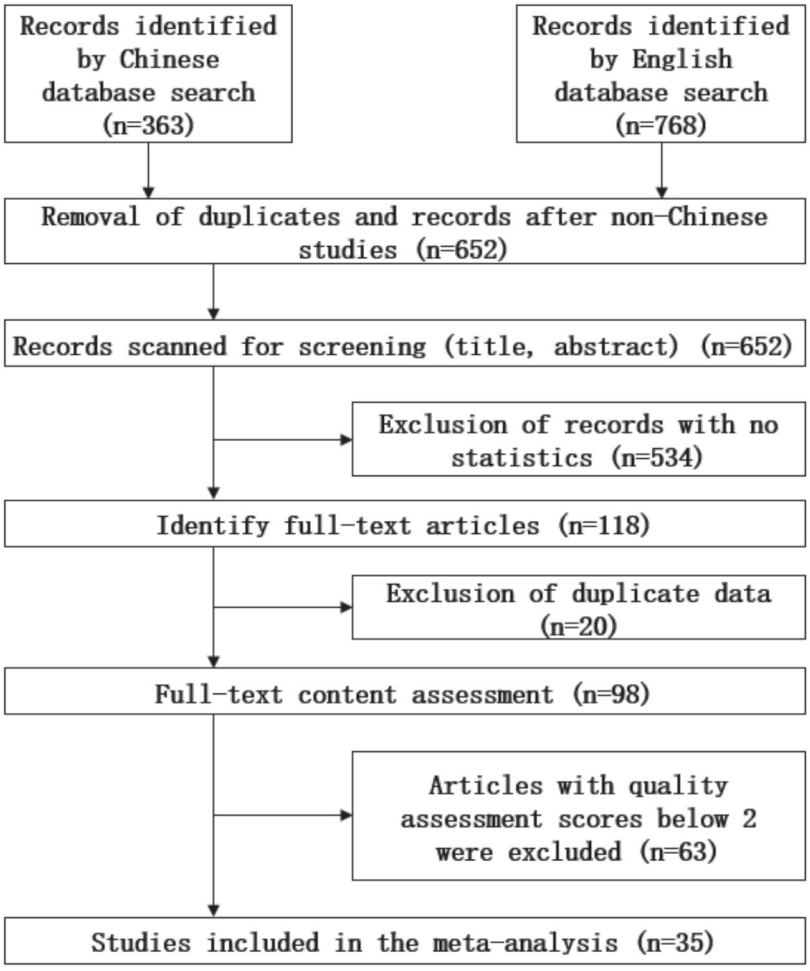

Fig. 2. Literature search protocol and results.

that if the literature size exceeded 30 and the sample size exceeded 70, the results of the meta-analysis would be accurate, reliable, and consistent. Therefore, the size of both the literature and the sample of this study meets the reliability requirements of meta-analysis.

Literature Coding and Data Processing

After the standard literature was obtained, the authors coded the literature together with another researcher familiar with Meta-analysis to ensure the independence and reliability of the data. The coded data included both qualitative and quantitative information types. Qualitative information included publication information descriptors of the author, publication year, and publication type, as well as sample characteristics of descriptors of measurement scope, measurement dimension, STI capacity, and degree of environmental regulation. Quantitative information includes sample size, and correlation coefficients (convertible correlation coefficients: e.g., β, R, T, etc.).

In this study, the data were processed and analyzed using the Comprehensive Meta-Analysis (CMA) 3.3 software, referring to the meta-analysis procedure of Lehrer et al. [44]. The correlation coefficient r was used as an effect size in this study. For cases where other statistical values are reported as effect sizes in the literature, conversion is required before entering the data. Among them, literature reporting t-values, standard errors, and standard deviations were directly converted to correlation coefficients using the CMA software. It is important to emphasize that the CMA software does not directly convert regression coefficients β. Regression coefficients can be converted to correlation coefficients and then entered into the CMA for analysis according to the conversion formula proposed by Peterson et al. [45]. Also, some studies report multiple effect sizes, making the study non-independent. Lehrer suggest that multiple outcome variables of the same dimension are reported in a study. Their mean values can be used. During the analysis, each ESr was converted to the corresponding Fisher z-value and then the weighted average of the Fisher Z-values was converted to a correlation coefficient to obtain the overall effect size. The specific conversion formula is as follows:

$$ES_r = r \tag{1}$$

$$ES_{Z_r} = 0.5 \log_e \left[\frac{1 + ES_r}{1 - ES_r} \right] \tag{2}$$

$$SE_{Z_r} = \frac{1}{\sqrt{n - 3}} \tag{3}$$

$$W_{Z_r} = \frac{1}{SE_{Z_r}^2} = n - 3 \tag{4}$$

where r is the individual correlation coefficient or average correlation coefficient, ES_{Z_r} is the correlation coefficient or average correlation coefficient of the corresponding individual Z_r transformations, e is the base of the natural logarithm and is approximately equal to 2.718, SE_{Z_r} is the standard error, W_{Z_r} is the inverse of the variance, and n is the total number of samples. The specific data are shown in Table 1.

Empirical Analysis

Overall Effect

Bias Test and Outlier Test

Bias test and outlier test. In conducting Meta-analysis, although this paper strictly followed the specific steps of Meta-analysis to conduct a literature search. However, due to the scope of database inclusion and personal subjective factors, not all empirical studies on the relationship between environmental protection input and ecological management efficiency could be obtained. This will create the corresponding bias problem. Therefore, in order to ensure the validity of the experimental results, a bias test is needed [73]. There are two methods for bias testing in academia at present. One is the funnel plot method, and the other is the fail-safe factor method. The principle of bias testing by funnel plot is that if all the papers are right on the top of the funnel and evenly distributed on both sides of the midline, the article is proven to be free from publication bias. The principle of bias testing by the fail-safe factor is that the larger the fail-safe factor is, the more reliable the findings are. In this paper, the articles were tested for bias in two ways separately. The funnel plot is shown in Fig. 3, and it can be seen that the results are mostly concentrated at the top of the funnel and evenly distributed on both sides of the midline, indicating that the possibility of publication bias is small. In addition, by the calculation results given by the software, the loss of safety coefficient of this study is 3344, which is much larger than the critical value of 185. Combining the two methods can conclude that the conclusion of this study is reliable.

In addition, we also performed outlier testing on the overall sample, and the forest plot of the overall sample was output through the software (Fig. 4), through Fig. 4, we can see that the effect values of the samples basically remained within the 95% confidence interval, and only two samples crossed the zero score boundary more obviously, and we did not perform any treatment on these two samples to ensure the integrity of the study.

Heterogeneity Test

The test of heterogeneity is an indispensable step in Meta-analysis, which examines the degree of difference between multiple independent samples. There are two

Table 1. Summary of studies on the relationship between environmental protection inputs and environmental governance efficiency.

First author	Time	Sample size	Effect Value	Standard error	Fisher·Z	Standard error
ShenRen Piao [46]	2017	130	0.158	0.087	0.159	0.089
Wenchao Yu [47]	2015	411	0.239	0.047	0.244	0.050
Liufang Xie [48]	2020	217	0.125	0.067	0.126	0.068
Tingjin Lin [49]	2010	468	0.131	0.046	0.132	0.046
Mian Yang [36]	2020	232	0.138	0.065	0.139	0.066
YunFei Xie [50]	2022	720	0.030	0.037	0.030	0.037
LuoDan Xu [51]	2018	372	0.023	0.052	0.023	0.052
Qin Wang [52]	2015	52	0.001	0.143	0.001	0.143
Wei Liu [34]	2021	180	0.536	0.054	0.599	0.075
YonHui Duan [53]	2021	110	0.082	0.096	0.082	0.097
ShiFen Li [54]	2020	88	0.024	0.108	0.024	0.108
LiHua He [55]	2016	576	0.001	0.042	0.001	0.042
Bin Wang [56]	2016	572	0.029	0.042	0.029	0.042
Kang Qu [57]	2019	377	0.137	0.051	0.138	0.052
Huang [58]	2020	165	0.043	0.078	0.043	0.079
GU [22]	2012	1890	0.007	0.023	0.007	0.023
HongWei Li [59]	2019	280	0.032	0.060	0.032	0.060
LiQi Yin [24]	2020	2109	0.057	0.022	0.057	0.022
Peng Zheng [60]	2022	1618	0.810	0.009	1.127	0.025
Yanhua Chen [25]	2020	260	0.066	0.062	0.066	0.062
Xue Chen [61]	2021	320	0.043	0.056	0.043	0.056
Zhijun Gu [29]	2021	399	0.029	0.050	0.029	0.050
Xianpu Xu [62]	2022	450	0.012	0.047	0.012	0.047
Juan Lu [63]	2020	4368	0.058	0.015	0.058	0.015
Junlan Tan [64]	2021	51	0.265	0.134	0.271	0.144
Yu Tu [65]	2019	143	0.020	0.084	0.020	0.085
Yue Zhu [66]	2022	660	0.036	0.039	0.036	0.039
Wang [67]	2015	330	0.469	0.043	0.509	0.055
YaFei Wang [68]	2011	300	0.601	0.037	0.695	0.058
ShiMing Zhen [69]	2017	290	0.012	0.059	0.012	0.059
GuoXiang Li [70]	2019	240	0.093	0.064	0.093	0.065
Jun Huang [5]	2018	270	0.110	0.060	0.110	0.061
Qun Lin [71]	2022	480	0.047	0.046	0.047	0.046
Xueping Wu [72]	2021	420	0.013	0.049	0.013	0.049
Ruiqian Li [17]	2020	360	0.107	0.052	0.107	0.053

methods for testing heterogeneity: a Q test and an I^2 test, and the principle of the Q test is to determine which model to use by comparing the magnitude of Q with the effect value K. Generally, when Q≤K-1, both models can be used. In general, when Q≤K-1, both models can be used. The rationale of the I^2 test is to describe the proportion of heterogeneity in the overall variance, i.e., the heterogeneity that arises after excluding random errors. In general, when I^2≥50%, heterogeneity is present and a random model is required. Conversely,

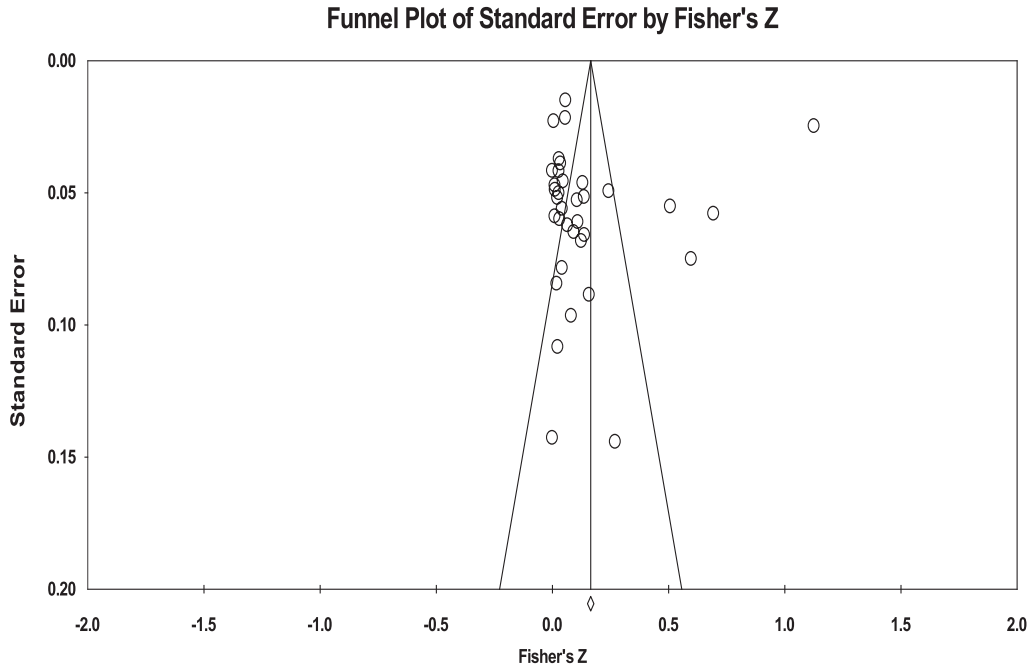

Fig. 3. Funnel diagram.

Meta Analysis

Study name	Subgroup within study	Correlation	Lower limit	Upper limit	Z-Value	p-Value
Bin Wang	0.000	0.029	-0.053	0.111	0.692	0.489
GU	0.000	0.007	-0.038	0.052	0.304	0.761
GuoXiang Li	0.000	0.093	-0.034	0.217	1.436	0.151
HongWei Li	0.000	0.032	-0.086	0.149	0.533	0.594
Huang	1.000	0.043	-0.111	0.195	0.548	0.584
Juan Lu	0.000	0.058	0.028	0.088	3.836	0.000
Junlan Tan	1.000	0.265	-0.011	0.504	1.881	0.060
Kang Qu	1.000	0.137	0.037	0.235	2.666	0.008
LiHua He	0.000	0.001	-0.081	0.083	0.024	0.981
LiQi Yin	0.000	0.057	0.014	0.099	2.619	0.009
Liufang Xie	0.000	0.125	-0.008	0.254	1.838	0.066
LuoDan Xu	0.000	0.023	-0.079	0.124	0.442	0.659
Mian Yang	1.000	0.138	0.009	0.262	2.102	0.036
Peng Zheng	1.000	0.810	0.793	0.826	45.292	0.000
Qin Wang	1.000	0.001	-0.272	0.274	0.007	0.994
Qun Huang	0.000	0.110	-0.010	0.226	1.805	0.071
Qun Lin	0.000	0.047	-0.043	0.136	1.027	0.304
Ruiqian Li	1.000	0.107	0.004	0.208	2.029	0.042
ShenRen Piao	1.000	0.158	-0.015	0.321	1.796	0.073
ShiFen Li	1.000	0.024	-0.186	0.232	0.221	0.825
ShiMing Zhen	1.000	0.012	-0.104	0.127	0.197	0.844
Tingjin Lin	0.000	0.131	0.041	0.219	2.841	0.004
Wang	1.000	0.469	0.380	0.549	9.200	0.000
Wei Liu	1.000	0.536	0.423	0.633	7.963	0.000
Wenchao Yu	1.000	0.239	0.146	0.328	4.925	0.000
Xianpu Xu	0.000	0.012	-0.081	0.104	0.254	0.800
Xue Chen	0.000	0.043	-0.067	0.152	0.766	0.444
Xueping Wu	0.000	0.013	-0.083	0.109	0.265	0.791
YaFei Wang	1.000	0.601	0.523	0.669	11.972	0.000
Yanhua Chen	0.000	0.066	-0.056	0.186	1.060	0.289
YonHui Duan	1.000	0.082	-0.107	0.265	0.850	0.395
Yu Tu	1.000	0.020	-0.145	0.183	0.234	0.815
Yue Zhu	0.000	0.036	-0.040	0.112	0.923	0.356
YunFei Xie	0.000	0.030	-0.043	0.103	0.804	0.422
Zhijun Gu	0.000	0.029	-0.069	0.127	0.577	0.564
		0.163	0.150	0.177	23.157	0.000

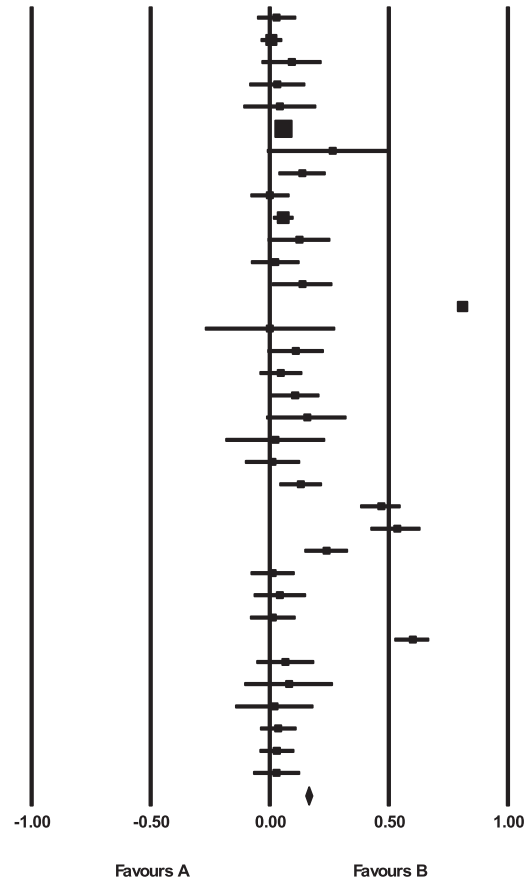

Fig. 4. Forest map.

Table 2. Overall effect heterogeneity test.

Model	Combined effect values	Number of effects	95%CI		Z	Heterogeneity test			
			Upper limit	Lower limit		Df	I^2	Q	P
Fixed	0.163	35	0.150	0.177	23.157	34	98.209	1898.46	0
Random	0.146		0.038	0.250	2.648				

there is no heterogeneity and a fixed model is used. In this paper, the inclusive effect heterogeneity is tested for both methods and the specific results are shown in Table 2. From the table, it can be observed that the Q value is 1898.46, which is much larger than the critical value of 34. I2 is 98.209, which is greater than 50%. Combining the two prove the existence of heterogeneity and the random effect model is used. Therefore, the combined effective value of the efficiency of ecosystem management is 0.146 with a 95% confidence interval of [0.038,0.250], which does not contain 0 and have a small interval. Meanwhile, the p-value is equal to 0, which indicates that the effect relationship is significant, i.e., environmental protection input has a significant effect on the improvement of ecological and environmental management efficiency.

Overall Effect Hypothesis Testing

Based on the heterogeneity test results, the overall effect hypothesis was tested using a random model. The exact results are shown in Table 3. From the table, it can be seen that the correlation coefficient between environmental protection input and eco-environmental management efficiency is 0.146 and the statistical result is significant ($p<0.01$), Thus, hypothesis H1 is verified. In addition, the correlation coefficient between financial environmental protection input and eco-environmental management efficiency is 0.292, the statistical result is significant ($P<0.05$), and the hypothesis H2a is verified. The correlation coefficient between corporate environmental protection investment and eco-environmental management efficiency is 0.056 and the statistical result is significant ($p<0.001$), and hypothesis H2b is verified. The above results indicate that most of the studies support a moderate positive correlation between environmental input and their subgenera and eco-environmental governance efficiency. Although this study can be controversial in the academic community, from a larger sample and over a longer period of time, environmental input as well as corporate and financial environmental input can effectively contribute to the improvement of eco-environmental governance efficiency.

Moderating Effects

Meta Binary Analysis

Meta-analysis of the study as a whole revealed heterogeneity among independent studies, which could suggest that the role of environmental input and their subgenera on the efficiency of ecosystem management is influenced by moderating variables. To verify this effect, this paper coded the literature in the form of 0 and 1 based on the different attributes of the moderating variables and then conducted a meta-binary analysis through the software. The exact results are shown in Table 4.

As can be seen in Table 4, for one, the correlation coefficient of 0.257 ($p<0.05$) between environmental protection inputs and eco-environmental governance efficiency measured nationwide with the province as the study unit is greater than the correlation coefficient of 0.045 ($p<0.001$) between environmental protection inputs and eco-environmental governance efficiency measured regionally with the city as the study unit, and it passed the heterogeneity test ($Q = 1898.46$, $p<0.001$), which indicates that the relationship between environmental protection inputs and eco-environmental governance efficiency is influenced by the scope of measurement, and the nationwide environmental protection inputs have a more significant improvement on eco-environmental governance efficiency, and research hypothesis H3 is verified. Second, the correlation coefficient of 0.166 ($P<0.05$) for the multidimensional eco-environmental

Table 3. Overall effect.

Category	Combined effect values	Number of effect values	Q	Df	P	95%CI	
						Upper limit	Lower limit
Environmental input	0.146**	35	1898.46	34	0.008	0.038	0.250
Enterprise environmental investment	0.056***	23	28.860	22	0	0.034	0.078
Financial environmental investment	0.292*	12	1343.972	11	0.045	0.007	0.534

Note:* indicates $p<0.05$; ** indicates $p<0.01$; *** indicates $p<0.001$. (Same below)

Table 4. Moderating effects.

Adjustment variables	Number of effect values	Effect Value	95%CI		Z	Heterogeneity test			
			Upper limit	Lower limit		Df	I^2	Q	P
H3: Measuring range	35	0.046	0.030	0.062	5.687	34	98.209	1898.46***	0
Region	19	0.045	0.029	0.061	5.562	18	0	13.189***	0
National	16	0.257	0.018	0.469	2.105	15	98.505	1003.659*	0.035
H4: Measurement dimensions	35	0.116	0.049	0.182	3.401	34	98.209	1898.46**	0.001
Single dimension	12	0.103	0.028	0.177	2.693	11	80.811	57.325**	0.007
Multidimensional	23	0.166	0.019	0.306	2.207	22	98.784	1808.74*	0.027
H5: Technology Innovation	35	0.045	0.022	0.069	3.806	34	98.209	1898.46***	0
Low	11	0.042	0.019	0.066	3.517	10	4.350	10.455***	0
High	24	0.188	0.026	0.340	2.273	23	98.653	1707.989*	0.023
H6: Environmental regulation	35	0.044	0.028	0.060	5.370	34	98.209	1898.46***	0
Low	18	0.043	0.027	0.059	5.231	17	0	11.491***	0
High	17	0.252	0.025	0.455	2.172	16	98.506	1070.996*	0.030

governance efficiency measurement is greater than that of 0.103 (P<0.01) for the unidimensional eco-environmental governance efficiency measurement, and it passed the heterogeneity test (Q = 1898.46, P<0.001), which indicates that the relationship between environmental protection inputs and eco-environmental governance efficiency is affected by the measurement dimension, and the multidimensional The hypothesis H4 is verified. Third, in the study of the relationship between environmental protection inputs and eco-environmental governance efficiency, the correlation coefficient of 0.188 (P<0.05) for the measurement sample with high STI is greater than that of 0.042 (P<0.001) for the measurement sample with low STI, and it passes the heterogeneity test (Q = 1898.46, P<0.001), indicating that the relationship between environmental protection inputs and eco-environmental governance efficiency The relationship between environmental protection inputs and eco-environmental governance efficiency will be influenced by science and technology innovation, and the improvement of eco-environmental governance efficiency is more obvious in regions with high science and technology innovation, and hypothesis H5 is verified. Fourth, the correlation coefficient of 0.252 (p<0.05) for the relationship between environmental protection inputs and eco-environmental governance efficiency under high environmental regulation is greater than that of 0.043 (p<0.001) for the role of low environmental regulation, indicating that the relationship between environmental protection inputs and eco-environmental governance efficiency will be influenced by environmental regulation, and the improvement of eco-environmental governance efficiency is more obvious for regional environmental protection inputs with high government intervention, and Hypothesis H5 is verified. Hypothesis H6 is verified.

Table 5. Meta regression analysis.

	Model 1		Model 2	
	Coef.	Std. Err.	Coef.	Std. Err.
Measuring range	0.2251***	0.0722	0.0893**	0.1620
Measurement dimensions	0.0744***	0.0590	0.0380**	0.1029
Environmental regulation			0.1288**	0.1537
Technology Innovation			0.0449**	0.1154
Q	20.68		19.45	
Df	2		4	
P	0		0.0006	

Meta-Regression Analysis

In order to further verify the validity of the above research hypotheses and the moderating effect of the moderating variables on the relationship between environmental protection input and the efficiency of eco-environmental management, this paper intends to use Meta-regression analysis to test again. The study was conducted in the form of a comparative analysis, and two models were selected for comparison. Model 1 includes measurement factors consisting of measurement range and measurement dimensions. In Model 2, in addition to the two variables of measurement factors in model 1, two mediating factors of STI and environmental regulations are added. The results of the regression analysis are shown in Table 5.

From Table 5, it can be seen that the overall test result in Model 1 is significant ($P<0.001$), which leads to significant results for the measurement range ($P<0.001$) and measurement dimension ($P<0.001$), and the regression coefficient is positive, further proving that the hypotheses H3, H4 are valid. The overall test result in model 2 is significant ($P<0.01$), which leads to significant results for STI ($P<0.01$) and environmental regulation with positive regression coefficients, further proving that hypotheses H5 and H6 are valid.

Conclusion and Outlook

Research Conclusions

First, the Meta-analysis of the overall effect shows that there is a significant positive relationship between environmental protection investment and eco-environmental management efficiency, which indicates that the state's increased investment in environmental management in recent years has effectively improved the eco-environmental pollution situation, thus further enhancing eco-environmental management efficiency. Secondly, a sub-study of the relationship between different types of environmental investment and eco-environmental governance efficiency shows that there is a significant positive relationship between corporate and financial environmental investment and eco-environmental governance efficiency, indicating that both corporate investment and government financial investment are conducive to the improvement of eco-environmental governance efficiency. However, the correlation coefficient of financial investment in environmental protection (0.292) is greater than that of corporate investment in environmental protection (0.056), which indicates that financial investment is more effective in improving the efficiency of eco-environmental management than corporate investment, mainly because the government, as the main body of eco-environmental management, plays an important role in eco-environmental management. Finally, the moderating effect of the relationship between environmental investment and eco-environmental governance efficiency was analyzed in four aspects: Measurement scope, measurement dimension, scientific and technological innovation, and environmental regulation. The study found that the moderating effects of the four aspects were obvious.

Policy Insights

(1) Increase investment in environmental protection and promote cooperation between government and social capital. As an important way to improve the ecological environment, ecological environmental protection projects have a significant role in improving the ecological environment. For this reason, the government can establish ecological environmental protection PPP projects through cooperation with social capital, which can share the financial pressure of the government and at the same time reduce the risk of project operation. In addition, enterprises can improve the efficiency of governance through professional management and continuous improvement of technology, and the government can invest in the form of financial subsidies, which can play a major role and gain social benefits. PPP projects as an effective way to invest in assets or future earnings as a guarantee, and the issuance of special bonds, as a way to finance, so that there will be a larger, longer-term fund into the environmental protection field projects.

(2) Play the main government guidance, the development of the environmental protection investment market. The government, as the main body of ecological and environmental governance, should give full play to the guidance role of its own financial investment. To this end, the government should improve the investment environment to create an orderly and fair environmental protection investment market; at the same time, play a decisive role in the allocation of resources by the market, mobilize the enthusiasm of various actors to participate in environmental protection investment, increase the attractiveness of the environmental protection market, and widely absorb social capital. For example, to provide financial support for eligible ecological and environmental protection projects such as air pollution prevention and control, water pollution prevention and control, solid waste treatment, and clean energy production. Market actors engaged in environmental protection will be included in the scope of policies such as tax exemptions, targeted subsidies, credit preferences, and talent support, as a way to promote the vitality of market actors' environmental protection investments.

(3) Facing regional economic differences to ensure the effectiveness of environmental protection investment. Due to geographical location, population, resources, and other factors, there are differences in economic development between different regions, and such differences make the sustainable development of the economy and society adversely affected. When ecological resources are divided based on

administrative divisions or when ecological resources have spillover effects, the efficiency of ecological and environmental management varies greatly from region to region. However, ignoring the differences between regions and seeking the same economic development between regions will lead to "free-riding" behavior, resulting in the undesirable situation that polluters are also beneficiaries. For this reason, in ecological and environmental management, the central government and decision-making departments should not only face the differences in regional locations but also pay attention to the differences in resource endowment and financial capacity between different regions, form matching top-level design, and institutional arrangements, and establish appropriate ecological and environmental cooperation mechanisms on the basis of recognizing regional differences, so as to maximize the benefits of investment in environmental protection funds.

(4) Increase scientific and technological innovation to enhance environmental governance capacity. First of all, we should increase the investment of scientific research funds and apply the research funds and resources to technological innovation. At the same time, we should ensure the quality of scientific and technological innovation, improve the supervision system of scientific and technological innovation through the Internet and big data, and conduct expert evaluation and assessment of innovation projects, and the evaluation process should ensure rigorous and standard. Second, vigorously promote the culture of science and technology innovation. Through publicity and other means to enhance the scientific literacy of all people, stimulate public awareness of innovation, and strive to improve the ability of independent innovation and the ability to identify "pseudo-innovation". Finally, base the scientific and technological innovation on real application. Because of the technical problems in the process of ecological environment management, through field investigation and analysis of the causes, characteristics, and effects of pollutants, we propose targeted management solutions and promote the transformation of environmental science and technology achievements, so as to improve the efficiency of environmental management.

(5) Improve the environmental regulation system and regulate ecological and environmental governance. The differences between different regions will form different types of environmental regulations, and different types of environmental regulations will have different effects on the efficiency of ecological and environmental governance in each region. Environmental pollution control will form an environmental regulation led by environmental pollution control investment, based on the "exclusive" property of environmental pollution control investment, which will inevitably have a certain crowding out effect on economic development investment, coupled with China's imperfect environmental protection system, unreasonable environmental protection capital investment structure, and ultimately will have a negative impact on the efficiency of ecological environmental control. The negative impact on the efficiency of ecological and environmental management. Therefore, the establishment of environmental regulation should take into account the actual situation of each region, and build different types of environmental regulation systems, combining government-based environmental regulation, market-based environmental regulation, and citizen participation-based environmental regulation to enrich the existing environmental regulation system and improve the environmental regulation system, so as to strengthen the supervision of ecological and environmental management.

Shortcomings

The main contribution of this paper is the integration of studies on the relationship between environmental protection input and the efficiency of ecological management, which theoretically solves the differences and discrepancies arising from different studies on this issue. At the same time, Meta-analysis, which is used in the medical field, is used as the research method of this paper, which makes the research method innovative and provides methodological ideas for the same type of research. However, it should be acknowledged that there are some shortcomings in this paper, mainly in the following aspects: On the one hand, due to research conditions and capabilities, this paper only analyzes the effects of environmental inputs on the efficiency of ecological management in the Chinese context, and although our findings are informative for countries with similar environmental conditions to China, there are limitations to replicating our findings in other countries. On the other hand, we recognize that the selection of moderating effects should be richer. In reality, there may also be cases where other factors influence the effect of environmental inputs on the efficiency of ecological management, such as whether the effect of the time factor should be considered in the selection of measurement factors, and whether the effect of fiscal decentralization, environmental interviews, and the level of economic development should be considered in the selection of mediating factors. However, our Meta-analysis could not include these factors because of the small amount of literature analyzing them, and more in-depth research is needed to obtain more evidence, so that we can expand our understanding of other moderating factors that influence the impact of environmental inputs on the efficiency of eco-environmental governance.

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Conflict of Interest

The authors declare no conflict of interest.

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