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The Effect of Government Environmental Auditing on the Efficiency of Green Development in the Yangtze River Economic Belt under the Background of Big Data

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Abstract: - The issue of environmental pollution has grown more noticeable due to the rapid expansion of our country's economy. The urgent demand for sustainable growth and the protection of ecological environment has arisen. In such a context, the role of governmental environmental audits is of utmost importance. This article is based on the background of the big data, from a variety of vantage points, this paper investigates the mechanisms and direct effects of government environmental assessments on green development efficacy in 108 localities along the Yangtze River Economic Belt (YREB). The study's results signify the following: (1) Government environmental evaluations substantially increase green development efficacy, even when no other control variables are taken into account. (2) The principal factors that impact such efficiency in the YREB are industrial structure upgrading and local government competition. (3) Robust tests conducted through variable substitution, estimation method replacement, and sample period alteration consistently yield significant results. This research holds significant implications for expanding the research perspective on governmental environmental audits, addressing ecological environmental issues, promoting high-quality green growth in the YREB, and achieving sustainable growth.

Keywords: Governmental Environmental Audit, Efficiency of Green Development, The YREB, Watershed, The Background of Big Data.

I. INTRODUCTION

Government environmental audits can leverage big data technology to comprehensively and precisely monitor the environmental conditions of the Yangtze River Economic Belt, providing robust support for green development. The utilization of big data empowers the government to accurately grasp environmental trends, promptly identify and resolve issues in real-time. It is crucial to enhance the extensive coverage of environmental responsibility audit supervision in the era of big data and establish and refine audit laws, regulations, and guidelines accordingly [1]. However, safeguarding data security and fostering technical talent are essential to ensure the seamless progress of government environmental auditing. In conclusion, big data technology brings unprecedented advantages to government environmental audits, infusing vitality into the green development of the Yangtze River Economic Belt.

As a globally influential inland economic belt, the YREB occupies a paramount position in our nation's main arena of environmental importance and sustainable growth, comprehensively advancing along the coast, the river, and the border. However, the YREB also encounters severe environmental challenges. Governmental environmental audit, serving as a supervisory mechanism for the environmental management practices of administrative bodies, assumes the tasks of environmental protection and oversight. As a critical instrument of national environmental governance, audit authorities drive and strengthen environmental audit work, making these mechanisms crucial for advancing governance in the environment and improving efficacy in YREB green development.

Governmental environmental audit enables the examination of the implementation of environmental policies, adherence to emission standards, and more, thereby providing scientific references and evaluations for the YREB's green development. Therefore, investigating the direct effects and mechanisms of governmental environmental

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audit on the YREB's green development efficiency holds significant value in advancing high-quality development, addressing ecological environmental issues, and achieving sustainable development in the region.

II. RESEARCH HYPOTHESIS AND THEORETICAL ANALYSIS

A. The Immediate Effects of Governmental Environmental Audit on the Efficiency of Green Development.

Environmental legitimacy theory is a theoretical framework for the study and examination of the legitimacy of environmental laws, rules and behaviors in the field of environmental management and protection[2].The theory explores the legal, ethical and social acceptance bases of legitimacy for environmental management and protection behaviors, and how to ensure that environmental decisions and actions comply with relevant laws and regulations, and are recognized and supported by society [3].Government environmental audits exert stronger pressure for environmental legitimacy at the level of compliance with laws and regulations, and government environmental audits assess businesses and organizations in the region to ensure that they comply with environmental laws and regulations. Audit results can reveal non-compliant behaviors and problems, and firms that violate environmental laws and regulations may face severe sanctions such as fines, penalties, or even closure, increasing the pressure for regional environmental legitimacy. The increased pressure on environmental legitimacy also makes higher demands on regional pollution emissions, and government environmental audits focus on the emissions and pollutant control of enterprises and organizations [4]. Through audits, pollutants found to be discharged in excess of standards or without proper treatment can lead to legal liability for the corresponding responsible units and penalties from the relevant regulatory authorities. This has prompted companies to be more cautious in controlling emissions and pollution and to strengthen environmental protection measures to meet statutory requirements, increasing the pressure on regional environmental legitimacy. Meanwhile, social supervision and public opinion also play a joint regulatory function, and the results of officially environmental audits usually attract public and media attention. If an audit finds that a business or organization has environmental problems or non-compliance, it may trigger questions and criticism from social opinion and the public. This public opinion pressure prompts businesses to focus more on environmental legitimacy and to take proactive environmental management and protection measures in order to safeguard their reputation and image.

When the pressure of environmental legitimacy is raised, it will produce competition effect and industry effect to promote green development, specifically: first, competition effect. The government environmental audit supervises disclosure of environmental information through regular inspection and random verification, finds problems and makes suggestions in time, continuously improves information disclosure [5], and develops local governments' disclosure of information quality regarding the environment. When local governments enhance the degree and quality of environmental information publication, citizens, enterprises, investors and social organizations can more clearly understand the government's environmental protection work, prompting the government to carry out environmental governance, concurrently, the regional government will also be compared with the results of environmental audits of other governments, to improve the credibility of the government to establish a good image, the government will raise the amount of money allocated in environmental protection to exceed the environmental situation of other governments, and improve the competitiveness of local governments. environmental situation, improve local government competition [6]. Second, industrial effect. The government environmental audit exerts stronger environmental governance pressure on traditional backward industries, prompts the greening and improving the local industrial structure [7], promotes the change of enterprises into eco-friendly and low-carbon areas, and guides the evolution of advantageous industries in the objective of environmental protection. Government environmental audits have increased the environmental importance of the government and citizens [8], pushed the government to formulate stricter environmental policies and regulations, strengthened supervision and enforcement, and at the same time guided citizens to actively participate in environmental protection actions.

From this, we formulate hypotheses:

H1: Government environmental audits can promote the efficiency of green development.

B. Mechanism Examination of Governmental Environmental Audits on the Efficiency of Green Development

1) Government environmental audits, competition between local governments and green development efficiency

Local government competition pertains to the strategic maneuvers undertaken by governments across diverse geographical areas to stimulate economic growth, attract investments, and develop their own competitive edge. This competitive behavior becomes an important means for regions to compete for resources and attract enterprises and talents [9]. In order to encourage the competition for financial progress, local governments will advance the

entry of foreign investment, promote the growth of high-tech sector, give full play to the innovation efficacy of enterprises, and attract more labor force employment among themselves by formulating tax incentives, as well as fostering the accelerated growth of the regional economy via infrastructure development support and other relevant sectors [10]. While setting up local environmental regulations, local governments are also able to formulate energy management policies to encourage energy conservation, emission reduction and energy transformation. For example, setting energy consumption targets, requiring enterprises and institutions to adopt energy-saving measures, advocating for the development and implementation of renewable energy sources and encouraging sustainable energy usage [11]. Smaller-scale governments can proactively foster and bolster the advancement of energy from renewable sources through the establishment of environmentally friendly infrastructure, including solar plants and wind farms. These facilities can replace traditional fossil energy sources, thereby reducing environmental pollution and promoting the transformation of the local economy into a clean energy industry [12]. Meanwhile, local governments can also increase investment in public transportation systems and build green transportation infrastructure for low-carbon travel such as rail transit and buses. This can help reduce personal car use, reduce traffic congestion and tailpipe emissions, and improve air quality [13].

From this, we formulate hypotheses:

H2: Government environmental audits can achieve green development efficiency by improving local government competition.

2) Government environmental audits, enhancement of industrial structure and green development efficiency

The objective of upgrading the industrial structure is to facilitate the transition and advancement of the economy from conventional industries to emerging industries that have high value-added, are technology-intensive, and driven by innovation. This process also strives to enhance the quality and efficiency of economic growth [14]. The fundamental principle of upgrading industrial structures is industrial restructuring, which entails raising the share of highly technological, value-laden, and knowledge-laden sectors while decreasing the share of conventional labor-intensive and resource-intensive industries in order to accommodate the requirements of economic progress. As an example, support for and development of new fields like information technology, biotechnology and new energy have been increased. While adjusting the structure, it is also vital to advance scientific and technological knowledge innovation, improve R&D investment, cultivate and introduce advanced technologies and innovations with core competitiveness, promote the improvement of the degree industrial technology, and realize the high-end extension of the industrial chain [15]. The government environmental audit can promote the synergistic development among enterprises in different segments and realize resource sharing and cooperative innovation [16]. Encourage financial institutions to increase investment support for green industries, set up special funds, provide low-interest rate loans and risk compensation mechanisms to attract more funds to flow into the field of green industries [17] and promote green development. Encourage the advancement of low-carbon technologies means of transportation, such as electric vehicles, hybrid vehicles and the improvement of the public transportation system, to reduce motor vehicle tailpipe emissions and improve transportation efficiency and air quality [18]. Besides, supply-side structural reform and labor structure transformation and upgrading are also important means to promote industrial structure upgrading. The supply structure is adjusted by eliminating backward production capacity, optimizing resource allocation, and promoting mergers and reorganization of enterprises, to raise supply chain efficacy and quality while fostering economic upgrading and revolution. At the same time, it is also vital to fortify the investment in training and education of human resources and increase worker skill levels [19]; meanwhile, to satisfy the requirements of burgeoning sectors, it is vital to develop talents with innovative and composite abilities to meet the requirements of industrial structure upgrading.

From this, we formulate hypotheses:

H3: Government environmental audits can realize green development efficiency by modernization of industrial structures.

III. MODELS, VARIABLES AND SAMPLES

A. Modeling

In light of the theoretical examination and the idea of research hypothesis, and in order to evaluate the impact of environmental evaluations by the government on the YREB's green development efficacy, this research establishes an empirical panel model. Green development efficacy serves as the research model's explanatory variable, with the government environmental audit constituting the central explanatory variable. The model for panel data can be presented below.

$$ED_{it} = \beta_0 + \beta_1 EA_{it} + \sum_{i=1}^{N} \beta_j control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{1}$$

In equation (1), GDit is the effectiveness of green development region i of 108 cities in the YREB in period t, EAit is the intensity of government environmental audits in region i in period t, and controlit is a control variable. Where each μ_i represents a unique fixed effects; γt represents time fixed effects; εit represents random error term.

To further examine if YREB cities' green development may be promoted by environmental auditing by the government via the influence local government competition and development industrial structures, as suggested in the analysis and hypotheses of the previous paper, this paper constructs a mediated effect model for estimation. Referring to the introduction of the mediation effect model by Wen Zhonglin and Ye Baojuan [20], the following are the primary stages. Green development efficacy is the explanatory variable, while the core explanatory variable becomes the environmental audit by the government. An increase in the latter's regression coefficient may serve as an incentive for the city to further its green development initiatives. Furthermore, industrial structure enhancement and competition among local governments function as intermediary variables. Consider the scenario in which the the government environmental audit's effect's regression coefficient with respect to the two intermediary variables listed above is substantially positive. The government environmental audit could then encourage competition among local governments and the modernization of industrial structures. In conclusion, the regression model incorporates the mediating variables and government environmental auditing concurrently in order to investigate their impacts on the efficacy of green development. Specifically, the following is the construction of the model:

$$ED_{it} = \beta_0 + \beta_1 EA_{it} + \sum_{i=1}^{N} \beta_j control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{2}$$

$$Med_{it} = \alpha_0 + \alpha_1 EA_{it} + \sum_{i=1}^{N} \alpha_j control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{3}$$

$$ED_{it} = \delta_0 + \delta_1 EA_{it} + \delta_2 Med_{it} + \sum_{i=1}^{N} \delta_j control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \tag{4}$$

Where GD_{it} is the green development efficiency of region i of 108 cities in the YREB in period t, EA_{it} is the relative importance of government environmental audits in region i in period t, Med_{it} is the mediating variable, i.e., competition among local governments and industrial structure upgrading, and $control_{it}$ is the control variable. μ_i denotes individual fixed effects;γ_t denotes time fixed effects;ε_{it} denotes random error term.

B. Variable Measurement

1) Explained variables

To ensure measurement bias-free reflection of efficacy in green development among the 108 communities designated by the YREB and to prevent radial and input (output) perspective selection influence, and at the same time to be able to measure the level of inputs and outputs under the consideration of resource and environmental constraints faced by the development of the city, this study employs super-efficiency SBM model, which generates undesirable outputs. The existence of n entities of decision-making is presumed, each of which consists of three parts: m input indicators, γ_1 desired output indicators and γ_2 non-desired output indicators. X, Y^d and Y^u are matrices where $X = [x_1, x_2, ..., x_n] \in R^{m \times n}$, $Y^d = [y_1^d, y_2^d, ..., y_n^d] \in R^{r_1 \times n}$ and $Y^u = [y_1^u, y_2^u, ..., y_n^u] \in R^{r_2 \times n}$, then the model expression is:

$$\min \rho = \frac{\dfrac{1}{m}\sum_{i=1}^{m}\dfrac{\overline{x}}{x_{dk}}}{\dfrac{1}{r_1 + r_2}\left(\dfrac{\sum_{i=1}^{n}\overline{y^d}}{y_{sk}^d} + \dfrac{\sum_{q=1}^{k}\overline{y^u}}{y_{qk}^u}\right)} \quad s.t. \quad \begin{array}{l} \overline{x} \geq \sum\limits_{j=1,\cdots,k}^{n} x_{ij}\lambda_j \quad i = 1,2,\ldots,m \\[2ex] \overline{y^d} \leq \sum\limits_{j=1,\cdots,k}^{n} y_{s_j}^d \lambda_j \quad s = 1,2,\ldots,r_1 \\[2ex] \overline{y^u} \geq \sum\limits_{j=1,\cdots,k}^{n} y_{qj}^u \lambda_j \quad q = 1,2,\ldots,r_2 \\[2ex] \lambda_j > 0 \quad j = 1,2,\ldots,n \\[1ex] \overline{x} \geq x_k \quad k = 1,2,\ldots,m \\[1ex] \overline{y^d} \leq y_k^d \quad q = 1,2,\ldots,r_1 \\[1ex] \overline{y^u} \geq y_k^u \quad u = 1,2,\ldots,r_2 \end{array} \tag{5}$$

ρ represents the YREB's efficiency in green development; as its value increases, so does green development efficiency. λ denotes the weight vector.

On the basis of the model, this article develops an input-output index approach for the green development efficacy among YREB cities. Drawing on the research of He Aiping and An Mengtian [21] and others, the specific input-output indicators are shown in Table 1:

Table 1: Input-output Indicators

Type of indicator	Level 1 indicators	Secondary indicators	Tertiary indicators	unit	note
inputs	Non-resource inputs	capital investment	capital stock	billions	The capital depreciation rate δ of 9.6% is computed utilizing Zhang Jun et al.'s (2004) perpetual inventory method.
		labor input	Employees of the unit	all the people	Unit personnel as of the year's conclusion
	Resource inputs	energy consumption	Electricity consumption of society as a whole	Million kWh	
		water resources consumption	Annual water supply	cubic meter (unit of volume)	
		Land consumption	Land area for urban construction	square kilometer	
outputs	Expected outputs	Level of economic development	gross regional product (GDP)	ten thousand dollars	Real GDP with 2004 as base period
	Non-expected outputs	three industrial wastes	Industrial wastewater discharge	ton (loanword)	
			Industrial SO2 emissions	ton (loanword)	
			Industrial fume (dust) emissions	ton (loanword)	

2) Explanatory variables

As the foundation for econometric analysis, the primary explanatory variable is "government environmental audit," which must be quantified. Referring to the existing research [22], by searching the keywords of ecology, natural resources, environmental protection, river-long system, water pollution, etc. in the audit situation of each city disclosed in China Audit Yearbook, if any keyword appears in the Audit Yearbook of a city, such city is deemed to have undertaken an environmental audit during that particular year. Based on this category of environmental audit keywords, this paper further summarizes the ratio of the number of occurrences of relevant government audit keywords in 108 cities in the YREB to the number of words in the text of the entire audit yearbook from 2008 to 2021, the reason being that in the high-context dissemination of culture in China, the linguistic meaning of the text can intuitively reflect the people's attitudes, views assertions, values, and appeals to a certain thing aspirations [6],. Therefore, this paper believes that the proportion of the frequency of text keywords can reflect the city's importance to environmental protection, pollution prevention and so on, i.e., the larger the proportion shows the stronger the importance, denoted as environmental auditing intensity by the government (EA1), subsequently defined and utilized as the principal explanatory variable for purposes of estimation.

3) Mediating variables

Local Government Competition (GC): In (actual per capita foreign capital usage)" to signify the degree of competition among local governments, as per the research methodology of Zhang Jun et al. [23].

Industrial structure upgrading (IU): measured using the share of value added of secondary industry output in GDP.

4) Control variables

Based Wang Min and Huang Ying [24], Fan Ziying and Zhao Renjie [25], and other finding, the following are selected for this article: (1) The foundation of regional progress is the economic level (EC), likewise referring to the degree of regional economic development. It also affects green development in the region, and a logarithmic measurement of regional GDP is utilized in this article. (2) Financial development (FD) is computed as the proportion of real GDP to the sum of all loans and deposits among financial institutions. (3) Education level (ED) is computed using the logarithm of public expenditure per capita on education in every city at the prefecture level.

(4) Human capital level (HCM) is the end-of-year ratio of each prefecture-level city's total population to the number of higher education students. (5) This paper measures the industrial structure (Ins), which is proximately associated with the region's green development, using the ratio of the tertiary industry's GDP to the secondary industry's GDP in each city at the prefecture level. (6) The extent of governmental involvement (Gov) in every city at the prefectural level, quantified by the ratio of financial expenditures in the locality to the general GDP. (7) Informatization level (Inf) is used as a control variable.

C. Study Sample and Descriptive Statistics

In consideration of the information accessibility pertaining to regional extent, the YREB is partitioned into eleven provinces, which are municipalities operating within central government jurisdiction and excludes incomplete data to get a total of 108 city research samples, of which Chongqing and Shanghai municipalities are separately as independent research units. In terms of the time frame of the study, considering that resource and environmental auditing was officially recognized as one of the auditing services in 2008, the present research employs panel data spanning from 2008 to 2021 and 2008 as the sample study's inception year to precisely assess the impact of environmental auditing by the government on green development. The data were compiled using prefecture-level audit reports from China Statistical Yearbook, China Audit Yearbook, and China Urban Statistical Yearbook, in addition to official audit bureau websites and 108 cities' statistical yearbooks. For the main variables, Table 2 presents the descriptive statistics. To mitigate the impact of anomalies on the regression outcomes, 1% up and down indentation provide support to the continuous variables.

Table 2: Descriptive Statistics for Each Variable

Variable	Mean	SD	Min	Max	p25	p50	p75	N
GD	0.427	0.191	0.177	1.121	0.309	0.379	0.476	1512
EA_1	0.032	0.057	0.000	0.297	0.000	0.000	0.039	1512
EA_2	0.471	0.499	0.000	1.000	0.000	0.000	1.000	1512
EC	51396.80	43080.63	7525.17	223529.40	22579.56	37086.58	64090.59	1512
FD	0.969	0.507	0.322	2.931	0.619	0.829	1.169	1512
ED	10.153	0.859	8.218	12.158	9.639	10.235	10.712	1512
Human	0.017	0.022	0.001	0.115	0.005	0.010	0.019	1512
Ins	0.921	0.377	0.362	2.473	0.655	0.856	1.096	1512
Gov	0.194	0.090	0.077	0.560	0.131	0.175	0.228	1512
Inf	1.094×10^7	3.849×10^7	60703.00	2.670×10^8	280000.00	630,000.00	1.724×10^6	1512

The GD mean in YREB over the past 14 years is 0.427, as shown in Table 1. This value is greater than 50 percentile, signifying that efficacy in green development for the majority of cities remains greater than the mean. With a standard deviation of 0.191, it further suggests the presence of internal variations. The mean value of EA1 is 0.032, and the standard deviation is 0.057. The mean value of EA2 is 0.471, which indicates that nearly 47.1% of the 108 cities studied in the YREB have carried out governmental environmental audits, which is closely related to the sustained attention paid by the audit departments of the government of the relevant cities to the YREB, a major national strategic region; however, the standard deviation is large. Inextricably linked; on the contrary, the substantial standard deviation signifies the evident discrepancy among cities. The control variables exhibit considerably larger standard deviations for economic and informationization levels, in contrast to the considerably smaller standard deviations for financial development, education level, human capital, industrial structure and government intervention are significantly smaller, suggesting that there are some similarities in financial development, education level, human capital, industrial structure and government intervention across the YREB. In addition, the mean value of education level is smaller than the 50% quantile, showing a left-skewed distribution, indicating that most cities have a disadvantage in education. On the contrary, economic level, financial development, human capital, industrial structure, government intervention and informatization level are all right-skewed distributions.

IV. RESULTS AND ANALYSIS

A. Direct Effect Estimates

Using Stata17 software, model (1) is regressed to estimate the factors affecting efficiency in green development of 108 cities in the Yangtze River Economic Zone, and the estimation results are shown in Table 3.As shown in Table 3, the estimated coefficients of the governmental environmental auditing-phase intensity EA1 are significantly positive when no control variables are added, indicating that the governmental environmental auditing has a significant enhancement of the efficiency in green development when other control variables are not

considered effect. The regression coefficients for models (2), (3), and (4), which represent the outcomes of time-fixed effects, individual fixed effects, and double fixed effects, respectively, are positive and satisfy 1% significance. Moreover, in accordance with the outcomes of the Hausman test, the two-way fixed effects model was selected as the ultimate model.

Significant at the 1% level, the regression coefficient of EA1 is 0.453, even when individual effects, time effects, and other control variables are controlled for. It implies that green development efficacy is correlated with the intensity of government environmental audit; in other words, cities that carry out government environmental audits among the 108 cities in the YREB tend to have higher levels of efficiency in green development. As an important supervisory and control mechanism of governmental environmental governance, governmental environmental auditing is of far-reaching significance for the effective implementation of its work and the prevention and control of pollution in local enterprises. Strict and standardized environmental audit can improve the pollution prevention and green awareness of local enterprises and residents, the more pressure and motivation to consciously strengthen environmental governance, the notion of "green mountains are golden mountains" regarding green development has the potential to profoundly resonate with individuals and subsequently be leveraged to deliberately cultivate a favorable public perception of the municipality. In summary, this paper's research hypothesis H1 is confirmed by the fact that the efficacy of urban green development can be substantially enhanced through increased environmental auditing by the government.

Table 3: Benchmark Regression Results

Variable	Model (1)	Models (2) time fixed effect	Model (3) individual fixed effect	Models(4) double fixed effect
EA1	0.4476***(4.75)	0.3746***(4.12)	0.4222***(6.04)	0.4531***(4.85)
EC		$-4.45 \times 10^{*-7}$(-1.91)	1.66×10^{-7}(0.43)	4.80×10^{-7}(0.91)
FD		-0.0558**(-2.58)	-0.0230(-0.57)	-0.0090(-0.18)
ED		0.0601***(2.86)	0.0040(0.35)	0.0919**(2.57)
Human		0.1693(0.36)	-0.1351(-0.25)	-0.2719(-0.47)
Ins		0.0644***(2.85)	-0.0184(-0.75)	0.0223(0.54)
Gov		-0.1286(-1.62)	0.0617(0.77)	0.0511(0.36)
Inf		3.43×10^{-11}(0.45)	-8.97×10^{-11}(-0.81)	-1.06×10^{-10}(-0.59)
Constant term (math.)		-0.1039(-0.60)	0.3566**(2.86)	-0.4687(-1.50)
individual effect	be	clogged	be	be
time effect	be	be	clogged	be
N	1512	1512	1512	1512

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively.

B. Mechanism Testing

1) Mechanistic test of local government competition

    a) Baseline regression analysis

The regression coefficient between environmental auditing by the government and green development efficacy in cities within YREB is 0.4531, as shown in Table 4. Furthermore, this coefficient satisfies 1% significance. Consistent with the baseline regression analysis outcomes presented in the preceding section, this result implies that environmental audits are being performed by the government to enhance green development efficacy. The results of Model 2 indicate that the regression coefficient of government environmental auditing on local government competition is 0.3522, which, again, passes the 1% significance level test, in other words, government environmental auditing can promote local government competition. Government environmental auditing's direct influence and local government competition's coefficient on green development efficiency are 0.2932 and 0.4539, respectively, as shown in Model 3. These values satisfy 1% significance. Consequently, local government competition's mediating effect is 0.1599 (0.3522×0.4539). Alternatively expressed, 35.29% of government environmental auditing's total impact on green development efficiency can be attributed to the mediating effect of local government competition. This means that government environmental auditing can improve efficiency in green development by promoting competition among local governments while other conditions remain unchanged. Therefore, local government competition is an important way for government environmental auditing to have an impact on efficiency in green development, and the research hypothesis H2: government environmental auditing can realize green development by improving local government competition is verified in the research hypothesis proposed in this paper.

Table 4: Mediating Effects of Local Government Competition

Variable	Model (1) GD	Model (2) GC	Model (3) GD
EA$_1$	0.4531***(4.85)	0.3522***(4.6371)	0.2932***(2.7785)
GC			0.4539***(3.2878)
control variable	be	be	be
constant term	-0.4687(-1.50)	9.0105***(9.3890)	-4.5584***(-4.3094)
individual effect	be	be	be
time effect	be	be	be
N	1512	1512	1512

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively.

b) Robustness test

The majority of scholars have developed methods for measuring local government competition as follows: Foreign direct investment (FDI) is initially employed to evaluate the level of competition among local administrations [26]. Local government competition is primarily for foreign investment, as FDI is a crucial to support the economic progress of China since the reform and opening up. The level of local government competition may be determined by calculating the ratio of FDI's regional actual utilization to regional GDP, or the ratio of the amount of regional actual utilization of FDI to the amount of national actual utilization of FDI [27]. ratio to express [28], this paper draws on Gong Xinshu et al. who chose to measure FDI by using the ratio of the amount of actual utilization of FDI to the regional GDP and converted it according to the annual average exchange rate of the RMB against the US dollar [29]. Previously, the logarithm of the amount of per capita real utilization of FDI has been used as a mediating variable, i.e., a proxy variable for local government competition to verify the existence of its mediating effect. Based on this, in order to further verify the robustness of its estimation results, the proportion of real utilized foreign investment in GDP is chosen as its proxy variable for testing. The regression results of the specific robustness test are shown in Table 5. The impact of the government environmental audit on local government competition remains positive. By employing actual foreign investment usage's proportion with respect to GDP as a surrogate local government competition's variable, this paper satisfies 1% significance. Based on the model (3) outcomes, the direct impact of the efficacy of environmental auditing by the government on green development is 0.434. Similarly, local government competition's coefficient with respect to green development efficact is 1.387. Both of these coefficients satisfy 1% significance. It denotes that government environmental auditing's effect on urban efficacy in green development is mediated by local government competition; in other words, with the increase in the intensity of government environmental auditing will enhance the efficiency in green development of the city by promoting local government competition. In summary, the above test results fully indicate that the research conclusion of this paper that there is a mediating effect of local government competition in the process of government environmental auditing affecting efficiency in green development is still robust through the method of variable substitution.

Table 5: Robustness Test for the Mediating Effect of Local Government Competition

Variable	Model (1)GD	Model (2)GC	Model (3)GD
EA1	0.453***(4.850)	0.0133***(2.633)	0.434***(4.581)
GC			1.387***(2.384)
control variable	be	be	be
constant term	-0.468(-1.50)	-0.009(-0.287)	-0.456(-1.436)
individual effect	be	be	be
time effect	be	be	be
N	1512	1512	1512

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively.

2) Mechanism test of industrial structure upgrading

a) Baseline regression analysis

The outcomes of industrial structure upgrading's mediating effect are presented in Table 6. The findings of Model (1)'s regression analysis align with the preceding section; at the 1% significance level, the cumulative impact of environmental auditing by the government on the efficacy of green development is 0.453. The model (2) outcomes indicate that government environmental auditing's coefficient with respect to industrial structure upgrading is 5.900, significant at the 1% level. The findings from Model (3) indicate that environmental auditing by the government has a direct effect of 0.395 on green development efficiency. Additionally, industrial structure upgrading has a significant impact coefficient of 0.009 on green development efficiency, with a 1% level of

confidence. Industrial structure upgrading has a mediating effect of 0.057 (5.9004×0.0097), accounting for roughly 12.63 percent of the overall effect. Similarly, other things being equal, government environmental auditing can significantly promote industrial structure upgrading, which in turn further promotes the efficiency in green development of the YREB. Therefore, industrial structure upgrading is also a key factor in the impact of government environmental auditing on efficiency in green development, which is consistent with the research hypothesis H3: government environmental auditing can realize green development by promoting industrial structure upgrading proposed in this paper.

Table 6: Modernizing the Industrial Structure's Mediating Effect

Variable	Model (1) GD	Model (2) IU	Model (3) GD
EA$_1$	0.4531***(4.85)	5.9004***(2.9280)	0.3959***(4.2393)
IU			0.0097***(3.9875)
control variable	be	be	be
constant term	-0.4687(-1.50)	41.7507***(3.7425)	-0.8732***(-2.5019)
individual effect	be	be	be
time effect	be	be	be
N	1512	1512	1512

Note: *, ** and *** indicating importance at the 10%, 5% and 1% levels, in that order.

b)   Robustness test

The prior study employed the proportion of value added by secondary industry output to GDP to be a mediating variable, or proxy variable for industrial structure upgrade, in order to examine its mediating effect. In light of this, the proportion of value rise in the secondary industry relative to the tertiary sector is chosen as a test surrogate variable in this paper in order to further validate the estimation results' robustness. The pertinent robustness test's regression outcomes are presented in Table 7. The ratio of secondary industry-contributed value to tertiary industry-added value is utilized as a proxy variable in this paper's analysis of industrial structure upgrading, as shown in Table 7. Government environmental auditing continues to have a substantial positive impact on the modernization of industrial structures, according to the findings. From the results of model (3), it can be seen that the direct effect of government environmental auditing on green development efficiency is 0.1541 and passed the 10% test of significance level, as well as the coefficient of influence of upgrade of industrial structure on efficiency in green development is 0.5886, which is significant at the 5% level. This shows that industrial structure upgrading plays a mediating role in the effect of government environmental auditing on urban green development efficiency. In other words, by enhancing how rigorously environmental audits are conducted by governments, the industrial structure upgrade of the city can be promoted, and this will improve the efficiency in green development of the city. In summary, the above test results fully demonstrate that the research conclusion that upgrade of industrial structure has an intermediary role in the procedure of government environmental auditing affecting efficiency in green development through the method of variable substitution remains robust.

Table 7: Robustness Test for the Mediating Effect on Upgrade of Industrial Structure

Variable	Model (1) GD	Model (2) IU	Model (3) GD
EA$_1$	0.4531***(4.85)	0.5075**(2.5257)	0.1541*(1.7377)
IU			0.5886**(2.1422)
control variable	be	be	be
constant term	-0.4687(-1.50)	0.0165(0.0592)	-0.4785(-1.5737)
individual effect	be	be	be
time effect	be	be	be
N	1512	1512	1512

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively.

C. Robust Tests

The reliability of the empirical results is crucial for this study, as it examines government environmental auditing's effect on the efficacy of green development. next, the model (1) will be tested for robustness in the following way, and Table 8 displays the empirical results.

1) Replacement variables

To evaluate the stability of the benchmark regression findings even more, this essay uses the method of replacing variables to re-examine the empirical test. Specifically, this paper replaces government environmental auditing as a dummy variable, and takes EA2 as 1 when a city in the Yangtze River Economic Zone implements government environmental auditing in year t, otherwise it is set to 0. Based on this, this paper defines it as the breadth of government environmental auditing EA2 by making reference to the custom of Zheng kaifang et al. and

re-estimates it as the core explanatory variable, and the results of the regression are displayed in Table 8. Based on the findings of the model (1), there is still a noteworthy positive association between the breadth of government environmental auditing and green development efficiency. audit breadth and efficiency in green development still show a significant positive relationship. Specifically, the regression coefficient is 0.0336 and surpasses the significance threshold of 1% level test. Compared with the benchmark regression results, the regression coefficient is slightly smaller, i.e., the intensity of government environmental auditing has a stronger effect on the improvement of efficiency in green development.

Table 8: Robust Test

Variable	Model (1) Breadth of government audits	Models (2) Tobit model	Models (3) 2008-2014	Models (4) 2015-2021	Models (5) Add lags
EA_1		0.3613***(4.17)	0.4136* (1.82)	0.3769***(3.38)	0.4249***(4.29)
EA_2	0.0336***(3.07)				
GD_{it-1}					0.0673**(2.07)
EC	$4.92 \times 10^{-7}(0.91)$	$1.03 \times 10^{-7}(0.38)$	$-7.80 \times 10^{-7}(-0.73)$	$1.09 \times 10^{-6}(0.89)$	$6.88 \times 10^{-7}(1.36)$
FD	-0.0141(-0.29)	-0.0212(-1.01)	-0.1811**(-2.41)	0.1985**(2.11)	-0.0039(-0.08)
ED	0.0952**(2.58)	0.0044(0.40)	0.1004*(1.77)	-0.0569(-0.63)	0.0850**(2.34)
Human	-0.1349(-0.23)	0.0272(0.07)	-0.8889(-0.56)	-0.2146(-0.34)	-0.2077(-0.34)
Ins	0.0251(0.60)	0.0081(0.40)	0.0663(0.62)	0.0483(1.02)	0.0165(0.39)
Gov	0.0585(0.41)	0.0226(0.28)	0.0416(0.26)	0.1384(0.41)	0.0590(0.39)
Inf	$-1.68 \times 10^{-10}(-0.91)$	$-1.31 \times 10^{-10}(-0.92)$	-5.20×10^{-9}***(-5.52)	-2.60×10^{-10}***(-1.36)	$-1.27 \times 10^{-10}(-0.73)$
constant term	-0.5086(-1.58)	0.3753***(4.07)	-0.4569(-0.92)	0.5749(0.61)	-0.4473(-1.36)
individual effect	be	be	be	be	be
time effect	be	be	be	be	be
N	1512	1512	756	756	1512

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively.

2) Replacement of estimation methods

Since the value range of efficiency in green development of 108 cities in the YREB in this essay is 0-1.3, which meets the Tobit regression model's initial conditions for the limited dependent variable, the panel for random effects Tobit configuration can be consistently estimated in contrast to the fixed-effects panel Tobit model. Therefore, this essay uses the random effects panel Tobit model to re-estimate the impact of government environmental audit intensity on efficiency in green development. The regression findings of model (2) in Table 8 show that the regression coefficient of government environmental audit intensity is 0.3613, which is test-passing at 1% significance level. This suggests that government environmental audit intensity is still greatly and positively related to urban efficiency in green development, again verifying the robustness of the benchmark regression results.

3) Change of sample period

Considering that the YREB became a major national development strategy in 2014 when the State Council's Guiding Opinions on Promoting the Development of the YREB by Relying on the Golden Waterway was released, and the regions along the YREB began to comprehensively focus on the construction of an ecological civilization demonstration belt, to be able to exclude the result of this policy, this essay takes it as a time window and divides the research sample into the years 2008-2014 and 2015- 2021 to re-estimate the results of government environmental audit intensity on efficiency in green development. According to the regression results of (3) and (4) in the model found in Table 8, the coefficients of regression remain robust. Specifically, the regression coefficients are 0.4136 for 2008-2014 and 0.3769 for 2014-2021 and are significant at 1% level. Further observation shows that after the implementation of the YREB strategy, the enhancement of green development efficiency is more significantly impacted by government environmental auditing.

4) Endogeneity test

In the first place, because areas with higher green development efficiency may force the government to carry out environmental audits, thus there is a two-way relationship among the explanatory factors and the explanatory variables, making the explanatory factors non-exogenous. Meanwhile, because green development efficiency is

impacted by multiple variables, the above regression model may have the issue of missing variables, which may trigger the endogeneity of the core explanatory variables. In order to solve this endogeneity problem, the first-order lag terms associated with the explanatory variables include introduced into the regression model as explanatory variables, drawing on the methodology used in existing studies. Since the first-order lag term is prioritized in time to the occurrence of the explanatory variable, the explanatory variable will not have an effect on it, thus correcting for the endogeneity problem. As shown in the model's regression outcomes (5), the regression coefficient of government environmental auditing after adding the explanation's first-order lag term variables is 0.4249 and passes the test of significance level of 1%, and the results of the study remain robust. Additionally, at the 5% significance level, the first-order lag term coefficient on green development efficiency is 0.0673, indicating how YREB's efficacy in green development during the preceding period improved the current period, and therefore the efficiency in green development of the YREB shows an obvious cumulative effect, which is consistent with the fact that the YREB, as a major national strategy, needs to be consistently implemented and realized.

V. CONCLUSIONS OF THE STUDY

A. Conclusions

Positive correlation exists between government environmental auditing and the YREB's green development efficacy. Regarding the overall result, the intensity of government environmental auditing is positively associated with the efficiency in green development, i.e., among the 108 cities in the YREB, the ones that have carried out government environmental auditing usually exhibit greater levels of efficiency in green development. It demonstrates that government environmental auditing possesses a substantial positive effect in encouraging efficiency in green development. And this study used various techniques such as replacement variables, replacement estimation model, time-period estimation and lag one period to conduct robustness test. The conclusions are consistent, indicating that the impact of government environmental auditing on efficiency in green development is robust.

Through the mechanism analysis, local government rivalry and improvement of the industrial structure are important mechanisms for audits by the government on environmental issues to influence the green development efficiency of the YREB. And the mediating effects of local government competition and industrial structure upgrading account for about 35.28% and 12.63% of the total effects of government environmental auditing affecting green development efficiency, respectively, which demonstrates that rivalry among municipal governments is the most important channel for environmental audits by the government to improve the efficiency of urban green development. Moreover, the mechanism robustness governing two intermediary variables—local government competition and industrial structure upgrading—is evaluated in this paper via the variable substitution procedure. The results suggest that the efficacy of green development in government environmental auditing is mediated by the two surrogate variables; thus, the study's findings remain strong.

B. Policy Suggestions

Strengthening the improvement of laws and regulations on government environmental auditing. First, by revising existing laws and regulations to fully reflect the current requirements and objectives of green development. Second, a more operational and binding indicator system should be established in order to bring the guiding and enforcement power of audits by the government on environmental issues into better play. Finally, the technical support and specialization of government environmental auditing should be strengthened. Government environmental audits need to employ contemporary information technology to its fullest means, strengthen data collection and processing capabilities, and build a sound environmental information system.

Improving the technical level and specialization of government environmental audits. Improving the technical level and specialization of government environmental audits is crucial to ensuring the scientific and effective nature of the auditing work. By making full use of modern information technology means, constructing a perfect environmental information system, and strengthening technical training and talent introduction, we can improve the efficiency of data collection and processing, provide reliable environmental data support, and at the same time, enhance the professionalism and skill level of auditors, so as to offer resolute backing for the effective execution of the government environmental audit. The implementation of these measures will promote the academic and logical nature audits by the government on environmental issues and facilitate the realization of green development and environmental sustainability.

REFERENCES

[1] Zhi J, Ma , Si Y, Liang, .Research on the Path of Achieving Full Coverage of Government Environmental Responsibility Audit Supervision in the Context of Big Data. Audit Research, 2015(05), 28-34.

[2] Suchman M C. Managing legitimacy: Strategic and institutional approaches. Academy of management review, 1995, 20(3): 571-610.

[3] Scott W R. Organizations and institutions. Research in the Sociology of Organizations, 1995, 2(5): 44-45.

[4] Xu Z,Dai Y,Liu W.Does environmental audit help to improve water quality? Evidence from the China National Environmental Monitoring Center. Evidence from the China National Environmental Monitoring Center. Science of The Total Environment, 2022, 823: 153485.

[5] Cai Chun, Zheng Open, Chen Ye, et al. Research on the impact of government environmental auditing on corporate environmental responsibility information disclosure--empirical evidence based on the environmental auditing of "three rivers and three lakes". Auditing Research, 2019(06): 3-12.

[6] Yang T,Liao H,Wei Y M. Local government competition on setting emission reduction goals. Science of the Total Environment, 2020, 745: 141002.

[7] WANG Wei,WEN Jie,SUN Fangcheng. Impact of government environmental audit on the green development of the Yangtze River Economic Belt. Yangtze River Basin Resources and Environment,2022,31(06):1187-1197.

[8] Zheng, X., Zhao, X.. Can government environmental audits promote regional pollution control? --Based on empirical evidence from Chinese prefecture-level cities from 2008-2018. Journal of Southwest University (Social Science Edition), 2022, 48(04): 130-138.

[9] Boyne G A. Competition and local government: A public choice perspective. Urban Studies, 1996, 33(4-5): 703-721.

[10] Zhou Ye'an. Local government competition and economic growth. Journal of Renmin University of China, 2003, (01): 97-103.

[11] Wu H,Li Y,Hao Y,et al. Environmental decentralization, local government competition, and regional green development: Evidence from China. Science of the total environment, 2020, 708: 135085.

[12] Xiong Bo,Chen Wenjing,Liu Pan,et al. Fiscal policy, local government competition and the quality of air pollution control. Journal of China University of Geosciences (Social Science Edition), 2016, 16(01): 20-33+170.

[13] Huang Maoxing,Li Junjun. Technology Choice, Industrial Structure Upgrading and Economic Growth. Economic Research, 2009, 44(07): 143-151.

[14] Wu N,Liu Z K. Higher education development, technological innovation and industrial structure upgrade. Technoogical Forecasting and Social Change, 2021, 162: 120400.

[15] Jiang Q,Tan Q.National environmental audit and improvement of regional energy efficiency from the perspective of institution and development National environmental audit and improvement of regional energy efficiency from the perspective of institution and development. Energy, 2021, 217: 119337.

[16] Xuefeng Shao,Tianshu Fang. Analysis of the coupling coordination degree of regional green finance and industrial structure--Based on the perspective of new institutional economics. Industrial Technology Economics, 2021, 40(01): 120-127.

[17] Li JM,Luo NS. Has the opening of high-speed railroad improved urban air pollution level?. Economics (Quarterly), 2020, 19(04): 1335-1354.

[18] Gong M,Zeng Y,Zhang F. New infrastructure, optimization of resource allocation and upgrading of industrial structure. Finance Research Letters, 2023, 54: 103754.

[19] WEN Zhonglin,YE Baojuan. Mediation effects analysis:Methods and model development. Advances in Psychological Science, 2014, 22(05): 731-745.

[20] He Aiping,An Mengtian. Local government competition, environmental regulation and green development efficiency. China Population-Resources and Environment, 2019, 29(03): 21-30.

[21] Cai Chun, Zheng Open, Chen Ye, et al. Research on the impact of government environmental auditing on corporate environmental responsibility information disclosure: Empirical evidence based on environmental auditing of "three rivers and three lakes". Auditing Research, 2019, (6): 3-12.

[22] Jun Zhang, Yuan Gao, Yong Fu, et al. Why does China have a good infrastructure?. Economic Research, 2007, (03): 4-19.

[23] Min Wang,Ying Huang. Environmental pollution and economic growth in China. Economics (Quarterly), 2015, 14(02): 557-578.

[24] Fan ZY, Zhao RJ. Can Strengthening the Rule of Law Promote Pollution Control? --Evidence from the establishment of environmental protection courts. Economic Research, 2019, 54(03): 21-37.

[25] Deng Yuping,Xu Helian. Foreign Direct Investment, Local Government Competition and Environmental Pollution: An Empirical Study Based on Fiscal Decentralization Perspective. China Population-Resources and Environment, 2013, 23(07): 155-163.

[26] Li Xiaolong, Xu Kun. Local government competition, environmental quality, and spatial effects. Soft Science, 2016, 30 (03): 31-35

[27] Gong Xinshu, Wang Man, Zhang Hongzhen FDI, market segmentation, and regional ecological efficiency: direct impact and spillover effects. China Population, Resources and Environment, 2018, 28 (08): 95-104

[28] Zhao Jianji, Liu Yan, Zhu Yakun, et al. The spatiotemporal pattern and influencing factors of the coupling of new urbanization and ecological environment in the Yellow River Basin. Resource Science, 2020, 42 (01): 159-171

[29] Xu Xianchun, Ren Xue, Chang Zihao. Big Data and Green Development. China Industrial Economy, 2019, (4): 5-22