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Balancing Environmental Sustainability and Economic Development: Perspectives from New Structural Economics

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Abstract: This paper explores the balance between environmental sustainability and economic development in the context of the Yangtze River Economic Belt (YEB) in China, a region pivotal to the country's industrial and environmental strategy. Utilizing New Structural Economics and the congruence index, we assessed the alignment between the local factor endowment structure and firm production input structure. Using the dataset of pollutant emissions from manufacturing firms in the YEB and focusing on key variables such as Chemical Oxygen Demand (COD) emissions and wastewater emissions, our findings indicate that firms with higher congruence demonstrate enhanced economic performance and alignment with comparative advantages. This alignment not only improves economic efficiency but also results in significantly reduced pollutant emissions, with a higher congruence index correlating with approximately 6.66% lower COD emissions and 5.39% reduced wastewater emissions per unit of industrial output. These findings offer valuable insights for policymakers and businesses, showing how alignment with local factor endowments can lead to mutually beneficial environmental and economic outcomes. The study contributes to the broader literature on environmental sustainability and economic development by demonstrating the practical application of New Structural Economics in a critical industrial region of China.

Keywords: congruence; environmental sustainability; economic development; pollutant emissions; comparative advantage

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1. Introduction

Addressing climate change and fostering green development are crucial challenges, especially for China, the world's largest developing country and a leading carbon emitter. China is currently at a pivotal point, committed to achieving "carbon peak and neutrality" as part of its modernization philosophy, emphasizing harmony between human activities and nature. This commitment highlights the urgent need for sustainable development and high-quality economic growth [1].

The Yangtze River Economic Belt (YEB) is an important region for China's economy and environment, but it faces big challenges due to its industries. The YEB, which includes 11 provinces and cities, is home to over 40% of China's people and constitutes more than 40% of its GDP. Unfortunately, it also faces environmental issues, primarily from chemical factories that pollute the Yangtze River. Addressing these environmental challenges is crucial for China's pursuit of high-quality economic growth.

This study, based on New Structural Economics, investigates the balance between environmental sustainability and economic development in the YEB. The framework of New Structural Economics guides our understanding of efficient and sustainable economic evolution through alignment with natural factor endowments. Our main focus is on the congruence index, which measures the alignment between local factor endowments and firm production input structures and is central to our analysis. We hypothesize that higher congruence levels, indicating closer alignment with comparative advantages, affect both the environmental and economic performance of enterprises in the YEB.

The study aims to find ways to help achieve the balance between environmental protection and economic growth, focusing on heavily polluting industrial enterprises. This study contributes to the existing literature by examining the benefits of aligning with local factor endowments for mutual economic and environmental outcomes.

This paper uses data from the Chinese Industrial Enterprises Database, Environmental Survey and Reporting (ESR) database, and China City Statistical Yearbook to build a micro-panel dataset of heavily polluting enterprises in the YEB from 1998 to 2012. It investigates the impact of the congruence index on the environmental and economic performance of these enterprises. The study finds that higher congruence index levels lead to better environmental performance. For example, a one standard deviation increase in the congruence index results in a 6.66% decrease in Chemical Oxygen Demand (COD) emissions and a 5.39% reduction in wastewater emissions per unit of output. This same increase is linked to improved economic performance, including an 8.09% increase in total industrial output, an 8.3% rise in main business revenue, a 10.5% increase in employee numbers, and a 2.14% rise in total factor productivity. These findings suggest that higher congruence index levels in the YEB lead to better environmental and economic outcomes. This contributes to high-quality regional economic development and achieving a win-win in environmental and economic performance. The study also observes that industrial agglomeration enhances the positive impacts of the congruence index in both areas.

In conclusion, this paper tackles a crucial academic question and offers insights for attaining high-quality regional economic development amid environmental challenges. By employing New Structural Economics and the congruence index, the study provides a comprehensive understanding of sustainable industrial development and practical guidance for both policymakers and businesses.

The structure of the paper is organized as follows: Section 2 presents a literature review. Section 3 introduces the data sources and main variables. Sections 4–6 cover the empirical results and analysis of the mechanisms. The final section concludes the paper.

2. Literature Review

This paper relates to the literature on studying the relationship between economic growth and environmental protection. A pivotal concept in this discourse is the Environmental Kuznets Curve (EKC) proposed by Kuznets [2], suggesting that environmental pollution remains relatively mild at the initial stages of a country's economic development. However, with rising per capita income, environmental pollution tends to initially increase, exacerbating alongside economic growth. Subsequently, beyond a certain economic threshold, further rises in per capita income start reducing environmental pollution, manifesting as an inverted U-shaped curve. Ongan et al. [3] used the Armey curve hypothesis (ACH) for testing the EKC. In the context of China's environmental landscape, consensus remains elusive on the timing of the EKC's turning point and the specific stage of economic development at which it will be reached, despite numerous empirical studies. The dilemma of balancing environmental pollution and economic growth is not exclusive to developing nations like China [4]. Historically, developed countries have grappled with similar challenges during their developmental stages [5]. Our findings contribute to the evolving field of economic research, reflecting the enduring influence of Hellwig's work [6] in understanding the complexities of economic development.

Presently, nations primarily deploy external environmental regulations to mitigate environmental pollution issues. Pollution's strong negative externalities are multidimensional. Upstream enterprises' pollution burdens downstream areas [7,8]. Intergenerationally, one generation's pollution impacts the next. Across industries, industrial pollution diminishes the productivity of agricultural enterprises [9]. This indicates a market failure in self-regulating for optimal outcomes, underscoring the necessity of government intervention in environmental matters. Following the introduction of the Scientific Outlook on

Development in 2003, the Chinese government has significantly elevated the priority of environmental concerns, intervening through a series of comprehensive environmental policies. These policies range from market-oriented pricing mechanisms—including carbon emission taxes, tiered energy pricing, incentives for energy-saving equipment, and green loans—to command-and-control measures like restricted market access for polluting industries, emission permits, and stringent environmental accountability and enforcement. In summary, through environmental regulations that constrain energy consumption and pollutant emissions of market entities, the government can effectively attain its objectives of energy conservation and emission reduction within the realm of economic development [10].

However, the debate over the effectiveness and economic costs of environmental regulations remains unresolved. First, many environmental regulations face strategic behaviors like "policy at the top, countermeasures at the bottom" [8,11,12], making it difficult to achieve the expected goals. For instance, during the "10th Five-Year Plan", local governments, in competition for tax revenue, reduced environmental criteria to attract investment. This led to a "race to the bottom" in enforcing environmental standards [13–15], ultimately failing to complete environmental tasks. Secondly, the issue of pollution transfer poses a significant challenge. Owing to territorial-based environmental regulation in China and uneven enforcement of standards, polluting enterprises often relocate across regions to evade strict governance [16]. For example, moving to the border of a downstream jurisdiction [8] or from the eastern coastal regions to the central and western regions [17]. Thirdly, while some environmental regulations effectively reduce energy use and emissions, they also incur considerable regulatory costs and economic losses. Numerous studies have confirmed the economic costs of environmental regulations. For instance, stricter water pollution regulations have led to a decline in regional labor market demand [18] and a decrease in enterprise productivity [11]. He et al. [11] estimated that a 10% reduction in China's total COD emissions might lead to an industrial output value loss of 159 billion USD. Therefore, this paper, informed by New Structural Economics, incorporates the congruence index as an internal driver in this discourse, proposing a novel approach to attain a win-win in environmental and economic performance.

Another stream of studies relevant to this paper is the research concentrating on the congruence index. Ju et al. [19] introduced a model of endowment-driven structural change, formulating a comprehensive growth model that incorporates a multitude of industries. Their model dynamically explains how the composition of these industries evolves endogenously over time, reflecting shifts in factor endowments. To determine whether an industry's factor intensity deviates from the economy's overall factor endowment, the model employs congruence to measure the alignment between local factor endowment structure and firm production input structure. Fundamentally, this index quantifies the gap between an industry's capital intensity and the nation's intrinsic capital abundance. Currently, the bulk of related research focuses primarily on the implications of such matching for economic performance. This paper endeavors to broaden this scope by examining the congruence index from both environmental and economic performance perspectives.

Hypothesis 1. *Firms with higher congruence levels are likely to increase economic efficiency and decrease pollutant emissions.*

3. Theoretical Framework

The micro foundation that supports the country's macroeconomic growth is technological progress, factor accumulation, and industrial upgrading [20]. This promotes the allocation of labor, capital, and other production factors to higher value-added technologies and industries, allowing the national economy and per capita income to continuously improve. The existing development economics often takes the industries and systems of developed Western countries as a benchmark and regards the differences between developing and developed countries as distortions that should be eliminated. This logic overlooks the endogenous structural differences between developing and developed countries, including both the differences in endowment structures and the structural differences in industries, technologies, hard infrastructure, and soft institutional arrangements inherent in endowment structures.

New structural economics believes that economic development is a dynamic process of resource accumulation and comparative advantage, constantly shifting from existing technologies and industrial allocation to more efficient technologies and industries with greater added value [19]. If a country's industry follows its comparative advantage in structural changes, it can produce products and provide services with comparative advantages at the lowest production factor cost. This provides the opportunity to form a competitive advantage and export to the international market. This economy will reach the most competitive state, create the maximum surplus, have the maximum return on investment, and accumulate capital factors at the fastest speed. The endowment structure and industrial structure of the economy will upgrade at the fastest possible speed [21–23]. On the contrary, if comparative advantage is violated, enterprises will lack self-sufficiency in an open competitive market and rely on long-term government protection subsidies to survive. Industrial upgrading is prone to failure [24,25].

Regarding the influencing factors of enterprise emission reduction, under environmental pressure, enterprises can adopt various emission reduction methods (such as green innovation, optimization of energy consumption, shutdown and reduction of production, enterprise relocation, etc.) to cope with it. From the perspective of environmental performance, these methods can all achieve emission reduction targets. However, when economic performance is taken into consideration, the strategies aiming at a win-win situation between environmental protection and economic performance, such as green technology innovation, investment in environmental protection facilities, and other emission reduction methods, differ vastly from another type of emission reduction approach that leads to conflicting dilemmas that sacrifice economic performance—such as companies reducing production, stopping work, relocating, and even exiting the market. Existing literature on the selection of different emission reduction methods by enterprises mainly focuses on describing this differential phenomenon, and further exploration of the underlying reasons has not been conducted [26].

Qiu et al. [27] explored the heterogeneity feedback of enterprises in responding to environmental regulations from the perspective of enterprise capability. Environmental regulations can lead to positive incentives for enterprises to increase technological innovation investment while maintaining their original production scale and negative effects on reducing production scale. The former positive effect often exists in high-capacity enterprises, while low-capacity enterprises often choose the latter, reducing production scale and even exiting the market. However, the sources of differences in corporate capabilities have not been further explored.

Whether the industry in which the enterprise operates conforms to the comparative advantage determined by local factor endowment is closely related to its self-sufficiency. Lin et al. [25] found that when the capital intensity of the industry in which a company operates is closer to the local factor endowment, the labor productivity, profit level, and TFP of the company are significantly higher. When the industry has a comparative advantage in local development, the input cost of factors is lower, and at the same time, it is more capable of technological innovation. On the contrary, if the factor intensity of an industry deviates from the economic endowment structure, it will require excessive use of scarce factors, resulting in high production costs, a lack of self-sufficiency in enterprises, and lower R&D innovation incentives.

However, there is relatively little research on the relationship between the development strategy of comparative advantage industries and environmental pollution, and it focuses on the macro level. Overall, existing research has found negative effects of development that go against comparative advantage on environmental governance, but detailed discussions on the micro-mechanisms have not yet been conducted. This article delves into the micro level of enterprises, studying how industrial development strategies affect environmental performance and the choice of emission reduction methods for enterprises. It considers the synergistic relationship between environmental regulatory tools and industrial policy tools. Environmental regulatory policies impose external emission reduction targets on enterprises, while industrial development strategies affect the internal willingness and ability of enterprises to meet environmental compliance. Enterprises that follow or violate the development strategy of comparative advantage industries will have significantly different emission reduction methods, explaining the economic and environmental target conflicts faced by enterprises in production activities in developing countries under increasingly strict environmental policies. Furthermore, at the macro level, from the perspective of the synergy between industrial development policies and environmental regulation policies, we provide ideas for building a win-win issue of environmental protection and economic development.

4. Data Sources and Main Variables

The focus of this paper, the Yangtze River Economic Belt, encompasses major regions of China including Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Yunnan, and Guizhou. Covering approximately 2.05 million square kilometers, it represents 21.4% of China's total land area. This area is an economic powerhouse, contributing over 40% to the national GDP. Specifically, from 2018 to 2022, the GDP from the belt's lower reaches (Shanghai, Jiangsu, Zhejiang, and Anhui) consistently formed about 24.1% of the national total, with the middle (Jiangxi, Hubei, Hunan), those from the upper reaches (Yunnan, Guizhou, Sichuan, and Chongqing) contributed around 11% and 11.2%, respectively. The region is a hub for emerging industries, particularly in electronics, information technology, and equipment manufacturing, each sector exceeding 50% of the national output in its field.

Moreover, the Yangtze River Economic Belt is critically significant from an environmental standpoint. It is one of China's most challenged areas in terms of water-related environmental issues, hosting numerous heavy chemical industrial parks and enterprises. These entities discharge a considerable volume of untreated industrial wastewater directly into the Yangtze River, exacerbating water pollution. Thus, studying the intricate relationship between economic growth and environmental protection in this belt is crucial for the high-quality development of China's economy. Research aimed at achieving a win-win in economic and environmental performance in this vital region holds immense importance.

4.1. Data Sources

To empirically examine the impact of factor structure matching degree on the economic and environmental performance of enterprises in the Yangtze River Economic Belt, this paper integrates data from three key sources: (1) the Chinese Industrial Enterprises Database, (2) the Environmental Survey and Reporting (ESR) database, and (3) the China City Statistical Yearbook. We meticulously selected data about enterprises within the Yangtze River Economic Belt, aligning them by their enterprise codes and respective city locations. This approach facilitated the creation of a comprehensive micro-panel dataset for the years 1998–2012, tailored for the empirical analysis required in this study.

The Chinese Industrial Enterprises Database provides crucial information about the region's industrial enterprises. This includes establishment dates, sizes, locations, types, and economic performance metrics like production capacity, profits, income, and other financial details. Crucially, it also provides data on the factor structure of these enterprises. The Environmental Survey and Reporting database contributes insights into enterprises' environmental performance, encompassing data on the generation, treatment, and emission of water and air pollutants. It also includes metrics on industrial waste and details regarding the acquisition and management of pollution treatment facilities and equipment. The China City Statistical Yearbook supplements this information with data on the factor endowments and structures of the cities where these enterprises are situated. Combining these diverse datasets enables the construction and analysis of indicators assessing the congruence between the industries of the enterprises and the factor endowments of the cities they are located in. This methodology offers intricate insights into the alignment of these enterprises' industries with the comparative advantages dictated by local factor endowments. Leveraging this data, the paper then methodically evaluates and discusses the influence of congruence on the economic and environmental performance of enterprises within the Yangtze River Economic Belt.

Based on the enterprise identification code, we matched the Chinese industrial enterprise database with the enterprise pollution database to form panel data. The selection of research years was determined to be from 1998 to 2012, mainly based on the following considerations. Firstly, during this period, China's environmental pollution problem gradually received attention, such as the proposal of the "Scientific Outlook on Development" strategy. Secondly, during this period, China's industrialization developed rapidly, especially after joining the WTO. The proportion of the secondary industry, which is an important source of pollution, increased rapidly and reached its peak. Thirdly, China has a relatively large proportion of industrial pollution sources. According to the "Second National Pollution Source Census Bulletin" jointly released by the Ministry of Ecology and Environment, the National Bureau of Statistics, and the Ministry of Agriculture and Rural Affairs in 2020, about 69% of the total number of various types of pollution sources in China come from industrial sources. In the end, a total of 239,571 observations were matched.

The panel data of enterprises in the Yangtze River Economic Belt, categorized by industry and regional distribution, is shown in Table 1. Enterprises from Zhejiang and Jiangsu provinces emerge as the most significant portion of the sample, demonstrating their substantial presence in the belt. This is followed by a notable representation from Sichuan and Hunan provinces. Conversely, the sample includes relatively fewer enterprises from Yunnan and Jiangxi provinces. In terms of industry distribution, the data highlight that the most prominent sectors in the sample are the manufacturing of chemical raw materials and chemical products, non-metallic mineral products, textiles, paper and paper products, and pharmaceutical manufacturing. These industries not only represent a significant share of the sample but are also critical from both environmental and economic perspectives. They are primary targets for water and air pollution monitoring due to their potential environmental impact, and simultaneously, they play a vital role in the economic fabric of the Yangtze River Economic Belt region.

Table 1. The top 10 industries and regional distribution of the sample.

Industry	Distribution (%)	Province	Distribution (%)
Manufacturing of Chemical Raw Materials and Chemical Products	13.98	Zhejiang	23.86
Non-Metallic Mineral Product Industry	12.51	Jiangsu	22.96
Textile Industry	11.04	Sichuan	11.47
Papermaking and Paper Products Industry	4.82	Hunan	7.90
Pharmaceutical Manufacturing	4.29	Hubei	7.56
Metal Products Industry	4.21	Shanghai	6.79
Processing of Agricultural and Sideline Food Products	3.86	Anhui	6.59
Smelting and Rolling of Ferrous Metals	3.70	Guizhou	4.48
Transportation Equipment Manufacturing	3.55	Yunnan	4.43
General Equipment Manufacturing	3.40	Jiangxi	3.95

4.2. Main Variables

The primary explanatory variable in this study is the congruence index. This index is formulated by gauging the disparity between the capital–labor ratio in a firm's industry and the capital abundance level of the city where it operates.

$$\text{congruence}_{\text{sct}} = -\left|\ln\left(\frac{K_{sct}}{L_{sct}}/\frac{K_{st}}{L_{st}}\right) - \ln\left(\frac{\overline{K_{ct}}}{\overline{L_{ct}}}/\frac{\overline{K_t}}{\overline{L_t}}\right)\right| \tag{1}$$

The construction of the congruence index is shown in Formula (1), representing the degree of matching in the element structure of the enterprise. The larger this indicator is, the more aligned it is with the comparative advantage determined by the local factor endowment of the industry. Among them, s represents the industry where the enterprise is located, t represents the year, and c represents the city where the enterprise is located. $\overline{K_{ct}}$ is the local fixed capital stock. $\overline{L_{ct}}$ is the local total number of employed people, and $\frac{\overline{K_{ct}}}{\overline{L_{ct}}}$ representing the local factor endowment structure, that is, the relative abundance of local capital. $\frac{\overline{K_t}}{\overline{L_t}}$ represent the relative abundance of national capital. $\frac{K_{st}}{L_{st}}$ is the average capital intensity of the S industry nationwide that year, representing the technological characteristics of the industry's factor investment.

$$\text{congruence}_{\text{st}} = \left|\frac{\frac{K_{st}}{L_{st}} - \frac{\overline{K_t}}{\overline{L_t}}}{\frac{\overline{K_t}}{\overline{L_t}}}\right| \tag{2}$$

Specifically, the factor structure matching index in this article is an enhanced version of the factor structure matching index at the country level proposed by Ju et al. [19]. It is utilized to assess whether a specific industry in a country aligns with or deviates from the comparative advantage determined by the factor endowment structure of the entire economy. Please refer to Formula (2) for details. Compared to the congruence indicators of Ju et al. [19], this article has made two improvements.

Firstly, the connotation of congruence has been expanded to the "city-industry-year" dimension. The factor endowment and industrial structure vary significantly across different regions of China, and local governments adopt diverse development strategies to guide regional industrial development. Therefore, researching factor matching at the regional industry level becomes necessary.

Secondly, in this paper's improved congruence index, the capital intensity of the industry where the enterprise operates and the level of regional capital abundance are both measured at the relative national level. This approach helps explain why industries with substantial differences in capital intensity can coexist in the same region.

For example, Guangzhou has both automobile and luggage clusters, benefiting from its status as a capital-rich region in China. The products or production links in Guangzhou's luggage industry are relatively more capital-intensive compared to the national average. These industries align with the local factor endowment structure, as reflected in the constructed element matching index in this article.

Additionally, to enhance the interpretability of the regression outcomes, the factor structure matching degree index has been standardized in this study.

The core variables in this paper fall into two categories: the environmental and economic performance of enterprises. In terms of environmental performance, we examine water pollution emissions through two indicators: COD emissions per unit of enterprise output and wastewater emissions per unit of enterprise output. Chemical oxygen demand (COD) emissions per unit output value serve as representative indicators for water pollution, measuring the organic material content in water. Higher COD values indicate more severe organic pollution, while increased wastewater emissions imply more intense pollution, reflecting poorer environmental performance.

During the research period from 1998 to 2012, the "Eleventh Five Year Plan" (initiated in 2006) defined quantitative emission reduction targets for pollutants such as COD and sulfur dioxide (SO_2). These targets were distributed to local governments at the provincial and municipal levels through hierarchical decomposition. The completion of these targets became part of a stringent system of hard constraints for official assessment and accountability, forming a crucial basis for local performance evaluation. Subsequently, in the "Twelfth Five Year Plan" and "The 13th Five Year Plan", additional emission reduction constraint indicators, such as ammonia nitrogen (NH) and nitrogen oxides (NOX), were introduced, continuing this strict enforcement framework.

For economic performance assessment, we considered indicators such as Industrial Total Output Value, Main Business Income, Operating Profit, Employee Numbers, and Total Factor Productivity. These indicators provide insights into an enterprise's production, operating health, profitability, employment size, and efficiency. Table 2 provides detailed explanations and data sources for these variables, while Table 3 presents the summary statistics.

Table 2. Descriptions of the main variables.

Variable	Description	Source
congruence	the alignment between local factor endowment structure and firm production input structure	Calculated by the authors
lnemicod_gdp	log (COD emissions per unit of output value)	Environmental Survey and Reporting database
lnemiww_gdp	log (wastewater emissions per unit of output value)	Environmental Survey and Reporting database
lngdp	log (industrial total output value)	Chinese Industrial Enterprises Database
lnrevenue	log (main business income)	Chinese Industrial Enterprises Database
lnprofit	log (operating profit)	Chinese Industrial Enterprises Database
TFP	total factor productivity	Calculated by the authors
age	enterprise age	Chinese Industrial Enterprises Database
SOE	whether the enterprise is state-owned	Chinese Industrial Enterprises Database
lnemployee	log (number of employees at year-end)	Chinese Industrial Enterprises Database
debt_asset	debt-to-asset ratio	Chinese Industrial Enterprises Database

Table 3. Summary statistics of the main variables.

Variable	Mean	Standard Deviation	Minimum	Maximum	Observations
congruence	0	1	−3.596	1.206	216,629
lnemicod_gdp	−0.276	2.547	−6.721	5.913	184,170
lnemiww_gdp	1.928	2.305	−12.417	14.962	207,293
lngdp	8.617	1.518	5.136	12.866	239,571
lnrevenue	10.893	1.512	7.489	15.181	239,324
lnprofit	7.699	2.187	2.197	12.953	173,469
TFP	5.888	1.203	−4.373	13.317	140,540
age	14.067	13.574	0	63	239,453
SOE	0.109	0.312	0	1	239,571
lnemployee	5.444	1.136	0	11.582	236,098
debt_asset	0.626	0.273	0.443	1.506	239,355

5. Empirical Results for the Environmental Performance

5.1. Baseline Regression

Table 4 presents the baseline regression results, illustrating the impact of the congruence index on the environmental performance of enterprises within the Yangtze River Economic Belt. In this table, Columns (1) and (2) utilize the intensity of COD emissions per unit of output value as the dependent variable, indicating water pollution emissions. Meanwhile, Columns (3) and (4) use the intensity of wastewater emissions per unit of output value as the dependent variable, offering a comprehensive measure of water pollution emissions. Both sets of indicators effectively capture the environmental performance of the enterprises. Notably, Columns (1) and (3) in Table 4 present results without control variables, while Columns (2) and (4) incorporate control variables such as the age of the enterprise, ownership type (state-owned or otherwise), size (measured by the number of employees), and the debt-to-asset ratio. The regression model also controls for city-by-year fixed effects and industry-by-year fixed effects, with standard errors clustered at the city-industry level.

The results consistently show that the congruence index negatively affects water pollution emissions per unit of output, regardless of the inclusion of control variables. This suggests that in the Yangtze River Economic Belt, a greater alignment between local resources and firm production inputs leads to better environmental outcomes. Specifically, a one standard deviation increase in the congruence index is linked to a 6.66% decrease in COD emissions and a 5.39% reduction in wastewater emissions per unit of industrial output.

Table 4. The congruence index and enterprise environmental performance: baseline regression.

Variables	(1) lnemicod_gdp	(2)	(3) lnemiww_gdp	(4)
congruence	−0.0843 ***	−0.0666 ***	−0.0593 ***	−0.0539 **
	(0.0222)	(0.0214)	(0.0222)	(0.0212)
Control	No	Yes	No	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes
Observations	169,816	169,044	189,323	188,499
R-squared	0.386	0.395	0.353	0.368

Note: standard errors are clustered at the city-industry level. The industry classifications are based on two-digit codes. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

The analysis of control variables in the regression yields several findings. Firstly, there is a positive correlation between the age of an enterprise and its pollution emission intensity, indicating that newer enterprises tend to perform better environmentally. Non-state-owned enterprises generally outperform state-owned ones in environmental metrics, and larger enterprises exhibit lower pollution emission intensity, suggesting better environmental performance. Conversely, a higher debt-to-asset ratio in an enterprise is associated with greater pollution emission intensity, suggesting that financially riskier enterprises might be less inclined or able to adopt energy-saving and pollution-reduction measures.

5.2. Robustness Check

The paper conducts four robustness tests to validate the basic regression results. The first test utilizes alternative water pollution indicators, such as NH, to assess environmental performance in the Yangtze River Economic Belt. The results, shown in Table 5, confirm the primary finding: the congruence index significantly reduces NH emissions per unit of output, indicating that better alignment of local resources with firm inputs leads to improved environmental outcomes.

The second robustness test expands the control variables to include additional factors impacting pollution behavior in the Yangtze River Economic Belt. Beyond enterprise age, ownership, and size, the test introduces variables like the enterprise's status as a Hong Kong, Macau, or Taiwan enterprise; foreign investment status; the ratio of fixed assets to total assets; and the capital–labor ratio. Results in Columns (2) and (3) of Table 5, which incorporate these variables, consistently show a significantly negative congruence index coefficient, reinforcing the primary conclusion that a higher congruence index significantly improves enterprises' environmental performance.

The third robustness test involves adopting a more granular industry classification. While the baseline regression primarily employed a two-digit code industry classification for controlling fixed effects and clustering, the analysis in Columns (4) and (5) of Table 5 transitions to using a three-digit code industry classification. The findings from this test confirm the robustness of the core conclusion, demonstrating that the congruence index significantly diminishes pollution emissions per unit of enterprise output, even under the scrutiny of a more detailed industry classification.

The fourth robustness test adjusts the regression year range to cover the period before 2010 due to changes in the data's definition and selection criteria post-2010. Columns (6) and (7) of Table 5 focus on observations from the pre-2010 period for the regression analysis.

The findings from this adjusted regression interval reveal that the sign and significance of the core regression coefficients remain consistent.

The outcomes from all four robustness tests consistently indicate that the coefficient for our primary indicator, the congruence index, is significantly negative. Such consistency across diverse testing methodologies solidifies the reliability of our core conclusion: within the Yangtze River Economic Belt, a greater alignment between local factor endowment structure and firm production input structure correlates with improved environmental performance. This repeated confirmation across different analytical approaches and scenarios underscores the robust nature of our findings, highlighting the importance of factor structure congruence in enhancing environmental outcomes for enterprises in the region.

Table 5. The congruence index and enterprise environmental performance: robustness check.

	Different Indicators	**More Control Variables**		**Three-Digit Code Industry Classification**		**Pre-2010 Period**	
Variables	**(1) lneminh_gdp**	**(2) lnemicod_gdp**	**(3) lnemiww_gdp**	**(4) lnemicod_gdp**	**(5) lnemiww_gdp**	**(6) lnemicod_gdp**	**(7) lnemiww_gdp**
congruence	−0.0615 **	−0.0517 ***	−0.0480 **	−0.0300 *	−0.0250 *	−0.0676 ***	−0.0541 **
	(0.0305)	(0.0200)	(0.0197)	(0.0162)	(0.0148)	(0.0215)	(0.0213)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77,872	168,282	187,693	168,953	188,416	168,643	188,086
R-squared	0.371	0.411	0.382	0.450	0.429	0.395	0.368

Note: standard errors are clustered at the city-industry level. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

5.3. Analysis of Mechanisms

Our analysis, including baseline regression and robustness tests, leads to a crucial conclusion: the congruence index positively impacts the environmental performance of enterprises in the Yangtze River Economic Belt. The following section explores the mechanisms underpinning how the congruence index affects water pollutant emissions. We hypothesize two primary mechanisms in this process.

The first mechanism suggests that industrial enterprises with higher congruence index levels are more likely to adopt cleaner production technologies and energy-efficient structures. This hypothesis is based on the idea that greater congruence leads to better alignment between the local factor endowment structure and the firm's production input structure, reducing factor input costs. Consequently, enterprises are incentivized to adopt cleaner and more energy-efficient production methods, resulting in lower pollutant generation. This mechanism was empirically substantiated by Cai et al. [28]. Their research methodically differentiated between the "generation" and "treatment" of pollutants. They delved into how the congruence index significantly reduces enterprise pollution emissions by investigating whether the decrease in pollutant emissions per unit of enterprise output resulted from adopting cleaner production technologies, leading to lower "initial generation" of pollutants, or from enhanced "end-of-pipe treatment" without altering production methods. The findings revealed that enterprises with a higher congruence index exhibited a significantly lower "generation" rate of pollutants per unit, with no corresponding increase in "end-of-pipe treatment". This indicates that the improvements in environmental performance are predominantly attributable to the reduced generation of pollutants at the source, achieved through the adoption of cleaner production technologies and methods.

Implementing internal and motivated strategies for emission reduction at the source signifies a more sustainable development approach. This is in contrast to enterprises that solely focus on meeting external environmental regulations. Those with a lower congruence index may encounter particular challenges due to their inherently weaker capabilities and heightened sensitivity to input costs. These enterprises might temporarily increase end-of-pipe pollution treatment to comply with stringent emission reduction targets during periods of rigorous environmental regulation. However, this approach can be less sustainable in the long term. When environmental regulations become less stringent, or when the intensity of environmental monitoring and enforcement fluctuates, these same enterprises may revert to their original, higher levels of pollution emissions.

Secondly, industrial enterprises in the Yangtze River Economic Belt with a higher congruence index are more inclined and equipped to invest in environmental protection facilities. This inclination is attributed to these enterprises being more aligned with local factor endowments' comparative advantages, due to the match between the capital intensity of their industry and the local abundance of capital. As a result, they possess stronger inherent capabilities [19] and are less dependent on external subsidies, making them more capable and willing to allocate resources towards environmental protection facilities and equipment, achieving better environmental performance. Cai et al. [28] empirically examined this mechanism in detail, assessing the purchasing and operational capabilities of a company's environmental protection facilities as the dependent variable. The findings demonstrate that a higher congruence index significantly boosts the likelihood of enterprises investing in environmental protection equipment. Specifically, an increase of one standard deviation in the congruence index elevates the average maximum daily processing capacity of a single set of wastewater treatment facilities by approximately 7.88% and of a single set of exhaust gas treatment facilities by about 12.6%. Moreover, enterprises with a higher congruence index exhibit stronger overall capacities for treating wastewater and exhaust gas.

6. Empirical Results for the Economic Performance

6.1. Baseline Regression

The previous section outlined the impact of factor structure compatibility on the environmental performance of enterprises. This section now shifts investigate how the congruence index influences the economic performance of industrial enterprises in the Yangtze River Economic Belt. The motivation for this inquiry is twofold: Firstly, achieving both economic and environmental performance is essential for the region's development, especially for the high-quality advancement of the Yangtze River Economic Belt. Secondly, in light of China's extensive pollution prevention and control campaign and its encompassing environmental regulations, it is crucial to examine the economic consequences of these measures. While these regulations have significantly improved environmental performance, existing environmental economics literature often suggests a trade-off with economic performance. This paper aims to provide a thorough and detailed assessment of the 'economic-environmental' impact within the Yangtze River Economic Belt, with a specific focus on how the congruence index plays a role. It seeks to offer new insights into how both economic and environmental aspects can achieve a win-win situation rather than being perceived as a trade-off.

For instance, He et al. [11] observed that enterprises located in the upstream areas of rivers in China, which are more easily monitored for emissions by water quality stations, face relatively stricter environmental regulations than those downstream. To mitigate emissions, these upstream enterprises often resort to using low-water-consumption technologies and reducing working hours. The study estimated that such adaptations could have resulted in an industrial output loss of approximately USD 130 billion in China between 2000 and 2007. This scenario prompts a critical consideration: if the improvement in environmental performance of enterprises, as discussed in this paper due to the congruence index, also incurs an economic cost, then steering industrial development to align with local factor structures might significantly affect its contribution to regional development. Hence, this section empirically explores the impact of the congruence index on the economic performance of industrial enterprises in the Yangtze River Economic Belt. It also examines whether the observed improvements in environmental performance, attributed to the congruence index, result from economic sacrifices associated with scaled-back industrial operations.

Table 6 displays the empirical results from the regression analysis, examining the impact of the congruence index on the economic performance of enterprises in the Yangtze River Economic Belt. The study utilized five key measures to reflect economic performance of the enterprises: (1) logarithmically transformed total industrial output value, indicating the production capacity; (2) logarithmically transformed main business revenue, reflecting the operating status; (3) logarithmically transformed operating profit, representing profitability; (4) logarithmically transformed total number of employees, indicating employment scale; and (5) total factor productivity, estimated using the LP method. The regression analysis indicates that a one standard deviation increase in the congruence index leads to approximately an 8.09% increase in industrial output value, an 8.3% increase in main business revenue, an 11.6% increase in operating profit, a 10.5% increase in the number of employees, and approximately a 2.14% increase in total factor productivity for enterprises in the Yangtze River Economic Belt. These findings suggest a significant positive impact of the congruence index on the economic performance of enterprises. Together with earlier findings on environmental performance improvement due to the congruence index, these results imply that aligning local factor endowment structure and firm production input structure is crucial for achieving a win-win in both economic and environmental performance. This insight holds particular relevance as China pursues for high-quality development and its "dual carbon goals", making these findings valuable for policy guidance. Furthermore, the analysis of control variables indicates that enterprises with larger employment scales, lower debt-to-asset ratios, and shorter operational histories tend to exhibit better economic performance.

Table 6. The congruence index and enterprise economic performance: baseline regression.

Variables	(1) lngdp	(2) lnrevenue	(3) lnprofit	(4) lnemployee	(5) TFP
congruence	0.0809 ***	0.0830 ***	0.1160 ***	0.105 ***	0.0214 ***
	(0.0118)	(0.0116)	(0.0150)	(0.0078)	(0.0079)
Control	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes
Observations	215,585	215,519	157,919	215,585	129,899
R-squared	0.658	0.663	0.493	0.247	0.476

Note: standard errors are clustered at the city-industry level. The industry classifications are based on two-digit codes. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

6.2. Robustness Check

The paper conducted comprehensive robustness checks on the basic regression results, specifically focusing on the congruence index and its association with enterprise economic performance. The first set of robustness regression introduced additional control variables to better consider factors influencing enterprise economic performance. Table 7, which includes augmented control variables, introduced factors such as the status of the enterprise as from Hong Kong, Macao, or Taiwan; its ownership status as a foreign enterprise; the ratio of fixed assets to total assets (indicating operational flexibility and profitability); and the enterprise's factor structure (capital–labor ratio). The results with these new controls, presented in Panel A of Table 7, columns (1)–(5), affirm that the coefficient of the congruence index remains significantly negative, reinforcing the core conclusion that the congruence index substantially enhances enterprise economic performance.

The second set of robustness tests involved a more granular industry classification. Utilizing a three-digit industry classification, the results in Panel B of Table 7, columns (1)–(5), consistently demonstrate that the congruence index significantly improves enterprise economic performance. This finding holds true even when considering more detailed industry classification controls.

Lastly, the third set of robustness regressions utilized sample data from years before 2010 to address concerns about potential impacts on estimation results due to changes in the selection criteria for large-scale enterprises in the China Industrial Enterprises Database post-2010. Analyzing pre-2010 observations in Panel C of Table 7, columns (1)–(5), the regression coefficient of the congruence index remains significantly positive, robustly supporting the conclusion that the congruence index significantly enhances enterprise economic performance.

Table 7. The congruence index and enterprise economic performance: robustness check.

Variables	(1) lngdp	(2) lnrevenue	(3) lnprofit	(4) lnemployee	(5) TFP
	Panel A: More Control Variables				
congruence	0.0815 ***	0.0839 ***	0.1120 ***	0.0938 ***	0.0449 ***
	(0.0116)	(0.0114)	(0.0145)	(0.0075)	(0.0078)
Control	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes
Observations	215,347	215,281	157,715	215,347	129,899
R-squared	0.666	0.671	0.505	0.263	0.503
	Panel B: Three-Digit Code Industry Classification				
congruence	0.0838 ***	0.0830 ***	0.1190 ***	0.1090 ***	0.0178 ***
	(0.0081)	(0.0078)	(0.0123)	(0.0071)	(0.0065)
Control	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes
Observations	215,508	215,442	157,832	215,508	129,844
R-squared	0.683	0.687	0.512	0.296	0.498
	Panel C: Pre-2010 Period				
congruence	0.0820 ***	0.0842 ***	0.1170 ***	0.1040 ***	0.0214 ***
	(0.0118)	(0.0116)	(0.0151)	(0.0077)	(0.0078)
Control	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes
Observations	214,988	214,922	157,476	214,988	129,899
R-squared	0.658	0.663	0.494	0.247	0.476

Note: standard errors are clustered at the city-industry level. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

6.3. Analysis of Mechanisms

We investigated two primary mechanisms through which the congruence index enhances the economic performance of enterprises in the Yangtze River Economic Belt. The first mechanism involves cost reduction. Enhanced congruence, as proposed by New Structural Economics, results in reduced factor input costs. The second mechanism is the promotion of research and development (R&D) and innovation. Enterprises that are aligned well with their comparative advantages, as dictated by local factor endowments, are more motivated to engage in R&D activities. With lower unit costs, these enterprises can improve profitability through productivity gains, especially after successful innovation despite the fixed costs associated with R&D. This not only enhances productivity but also boosts profitability, providing a strong incentive for pursuing R&D and innovation.

Lin et al. [29] conducted a detailed empirical validation of these two mechanisms in their research. To assess cost reduction, the study used three cost metrics: annual total wages payable, labor costs, and administrative expenses. These metrics were normalized using different scale indicators, specifically the enterprise's sales, total output, and added value. The results consistently demonstrated that the congruence index significantly reduces enterprise costs. In evaluating the congruence index's influence on R&D and innovation, the study examined four variables: R&D intensity, the proportion of new product output value to total output, patent applications, and invention patent applications. The regression outcomes revealed that the congruence index substantially fosters enterprise innovation and R&D intensity. Specifically, a one standard deviation increase in the congruence index could enhance the R&D investment-to-sales ratio by 0.01% (from a mean of 0.19%), elevate the proportion of new product output value to total output by 0.21% (from a mean of 4.34%), and increase the number of patent applications by 0.5%, including a 0.1% rise in the number of invention patent applications. This series of empirical analyses clarifies the precise mechanisms through which the congruence index enhances enterprise economic performance. Combined with findings from the first two sections, it is evident that the congruence index improves both the environmental and economic performance of enterprises. This contributes to high-quality development and a win-win situation in both economic and environmental aspects, underscoring the multifaceted benefits of aligning industrial development with regional factor endowments.

7. Extension: Industrial Agglomeration, the Congruence Index, and the "Economic-Environmental" Win-Win

This section provides an exploratory analysis of how local government actions, such as creating development zones and choosing key industries for clustering, influence industrial agglomeration. Li and Shen [30] highlighted that industrial agglomeration is a pivotal driver of technological innovation and industrial upgrading in China. With the growing concentration of industrial pollution sources in these development zones, their environmental and economic performance has become increasingly critical. As such, this section evaluates whether the positive effects of the congruence index on environmental and economic performance are evident within these zones, using development zones as typical examples of industrial agglomeration. We suggest that industrial agglomeration enhances the benefits of the congruence index on environmental-economic performance through several mechanisms.

Firstly, industrial agglomeration lowers local transaction costs. This helps transform comparative industrial advantages into competitive advantages [31]. This not only elevates economic benefits but also means that enterprises with higher congruence index levels experience even lower factor input costs. Consequently, these enterprises are more inclined and able to invest in environmental protection facilities.

Second, industrial agglomeration generates technological spillover effects, which contribute to innovation and productivity improvements, thus bolstering economic performance. Regarding environmental performance, such agglomeration can lead to the dissemination of clean technologies. Enterprises with a higher congruence index are better equipped and more willing to embrace cleaner production technologies, resulting in a reduction in pollutant generation at the source.

Third, the unit cost of pollution treatment in industrial clusters may be lower, making it more feasible for enterprises. Hence, when enterprises in an industrial agglomeration zone exhibit a high congruence index, they are likely more motivated and capable of enhancing their investments in environmental protection facilities.

In this analysis segment, we conducted a subsample regression. It focused on enterprises within the Yangtze River Economic Belt's development zones. The identification and classification of these enterprises relied on the "China Development Zone Audit Announcement Catalog". The process of matching enterprises to their respective development zones utilized postal codes, with a supplementary check on whether the detailed address fields of the enterprises contained references to "development zone". The regression outcomes, as presented in Table 8, are in line with our hypotheses. When examining pollution emission intensity per unit of enterprise output value as the dependent variable, the coefficient of the congruence index was significantly negative. This result indicates an improvement in environmental performance for enterprises within these development zones. Conversely, when assessing variables linked to economic performance, the coefficient of the congruence index was significantly positive. This finding underscores that the congruence index substantially enhances both the environmental and economic performance of enterprises in the development zones.

These findings carry important implications for local governments in their strategic planning of leading industries within development zones. It is crucial for these industries to be in sync with the local capital abundance and to align with the comparative advantages defined by local endowment structures. Such alignment is not only essential for fostering economic growth driven by local industrial agglomeration but also plays a significant role in improving local environmental conditions.

Table 8. Industrial agglomeration, the congruence index, and the "Economic-Environmental" win-win.

	Environmental Performance				**Economic Performance**			
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	lnemicod_gdp		**lnemiww_gdp**		**lngdp**	**lnrevenue**	**lnprofit**	**lnemployee**
congruence	−0.116 ***	−0.0817 **	−0.0828 **	−0.0516	0.0495 **	0.0530 **	0.1230 ***	0.1070 ***
	(0.0365)	(0.0354)	(0.0347)	(0.0339)	(0.0219)	(0.0220)	(0.0328)	(0.0217)
Control	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Industry× Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City× Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,069	24,951	26,423	26,302	28,834	28,834	23,498	28,834
R-squared	0.405	0.419	0.382	0.397	0.648	0.654	0.495	0.279

Note: Standard errors are clustered at the city-industry level. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

8. Conclusions

8.1. Summary of Key Findings

This study, utilizing the lens of New Structural Economics, has focused on the Yangtze River Economic Belt, constructing a congruence index to measure the alignment between local factor endowments and firm production input structures. The main findings include:

Environmental Performance: Enterprises with higher congruence index levels demonstrate superior environmental performance. Specifically, a one standard deviation increase in the congruence index correlates with a reduction of approximately 6.66% in COD emissions and a 5.39% decrease in wastewater emissions per unit of industrial output. This reflects the positive impact of alignment with local factor endowments on adopting cleaner production methods and investing in environmental facilities.

Economic Performance: Similarly, a higher congruence index is associated with enhanced economic performance. This is evidenced by an approximate 8.09% increase in total industrial output, an 8.3% rise in main business revenue, an 11.6% growth in operating profit, a 10.5% increase in employee count, and a 2.14% improvement in total factor productivity.

Impact of Industrial Agglomeration: The study also underscores that industrial agglomeration intensifies the positive effects of the congruence index on environmental and economic performance. This highlights the role of industrial agglomeration in complementing the alignment of industrial development with local factor endowments.

8.2. Policy Recommendations

The policy implications suggest that enhancing the congruence index, as opposed to solely relying on external environmental regulations, can significantly motivate enterprises internally. This motivation encourages the voluntary adoption of cleaner production technologies and investment in environmental facilities, leading to a sustainable trajectory of high-quality development without sacrificing economic growth.

Local governments, while attracting investment and formulating industry policies, should consider the potential industries' alignment with local factor endowments. This approach is more advantageous than indiscriminately pursuing high-tech industries. For effective industry clustering in development zones, aligning with local factor endowments is crucial as it fosters both economies of scale and the achievement of environmental objectives alongside economic growth.

9. Acknowledgment of Limitations

Despite these insights, this paper recognizes certain limitations. For instance, while New Structural Economics encompasses a broad spectrum of endowments, this research primarily concentrates on factor endowments due to data constraints. Aspects like institutional endowments have not been extensively explored. Future studies aim to broaden the scope of analysis to include a more comprehensive range of endowment-related factors, thereby enhancing the depth and breadth of understanding in this area.

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