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Article

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

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Abstract: This paper investigates the critical factors for balancing environmental sustainability and economic development through the lens of New Structural Economics. Specifically, we utilize the congruence index to access the alignment between local factor endowment structure and firm production input structure. Using a comprehensive manufacturing firm-level pollutant emissions dataset from the Yangtze River Economic Belt (YEB) region in China, we find that firms demonstrating higher congruence exhibit improved economic performance and alignment with comparative advantages. This not only contributes to increased economic efficiency for these firms but also leads to a reduction in pollutant emissions, including wastewater discharge and Chemical Oxygen Demand (COD) emissions. Our study provides valuable insights into achieving mutually beneficial environmental and economic outcomes.

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

1. Introduction

Confronting climate change represents a critical and urgent challenge for human society in the 21st century, with advancing green development emerging as a globally recognized imperative. Currently, China is at a pivotal point in accelerating its transition to sustainable development practices and promoting high-quality economic growth. China, as the world's largest developing country and leading carbon emitter, has pledged to achieve "carbon peak and neutrality." This commitment underscores its firm resolve to adopt and implement a new development philosophy. The report of the 20th National Congress of the Communist Party of China states: "Chinese modernization is the modernization of harmony between humanity and nature." It emphasizes that "Respecting, adapting to, and protecting nature is essential for building China into a modern socialist country in all respects." Strategically, there is a need to "accelerate the transition to a model of green development, promoting concerted efforts to cut carbon emissions, reduce pollution, expand green development, and pursue economic growth." Additionally, the 14th Five-Year Plan explicitly proposes "to achieve the objectives of China's Intended Nationally Determined Contributions 2030, and to coordinate efforts to drive high-quality economic development and high-level ecological environment protection."

The simultaneous advancement of high-quality economic development and ecological environment protection represents not only a classic academic concern but also an urgent real-world challenge for China. As the world's leading manufacturing nation and largest exporter of goods, China has assumed a responsibility for pollution reduction and carbon emissions that far surpasses the usual commitments of developed countries. At present, China confronts interrelated challenges encompassing industrialization, urbanization, ecological sustainability, and low-carbon development. This complexity necessitates a coordinated approach that integrates industrial

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transformation, economic growth, and concerted efforts in pollution and carbon reduction. This paper, grounded in the framework of New Structural Economics, employs the congruence index to measure the alignment between local factor endowment structure and firm production input structure. More specifically, a higher congruence suggests that the development of local industries is more closely aligned with their comparative advantages. Focusing on heavily polluting industrial enterprises in the Yangtze River Economic Belt (YEB) region, this study examines how the congruence of industrial development strategies with local capabilities influences the environmental and economic performance of enterprises in this area.

Stretching across 11 provinces and cities in China's eastern, central, and western regions, the Yangtze River Economic Belt is home to over 40% of the nation's population and accounts for more than 40% of its Gross Domestic Product (GDP). This strategic positioning renders it a pivotal engine for China's economic development. Conversely, this region also harbors numerous chemical industrial parks and enterprises, resulting in a significant discharge of industrial wastewater into the Yangtze River basin. Tackling the pollution challenges within the Yangtze River Economic Belt constitutes a critical component of China's nationwide pollution prevention and control campaign. Thus, in the context of a global economic slowdown and increased uncertainty, and as China's economy shifts from rapid growth to a focus on high-quality development, it is crucial to investigate strategies for fostering such development in the Yangtze River Economic Belt. This research aims to identify pathways to achieve a dual win in terms of the economic and environmental performance of enterprises, a goal of utmost significance.

Prior research in environmental economics has thoroughly examined the trade-offs between economic growth and environmental safeguarding, particularly focusing on the economic implications of environmental regulation. The negative externalities of pollution, exemplified by downstream entities suffering from upstream business pollution [1,2], complicate market decision-making, thereby underscoring the necessity of governmental environmental regulations in effective environmental governance. Indeed, China's rapid GDP growth in the three decades following its economic reform and opening-up has coincided with escalating environmental challenges and the adoption of more stringent environmental regulations. Beginning in 2003, the implementation of nationwide automated environmental monitoring and the systematic public disclosure of pollution data have intensified the supervision of environmental issues. The 11th Five-Year Plan, introduced in 2006, set specific energy-saving and emission reduction targets for provinces and cities. These targets were integrated into local government performance evaluations as mandatory constraints, thereby bolstering environmental regulation initiatives from the central to local governments. The effectiveness of stringent environmental regulations is evident. Throughout the 11th and 12th Five-Year Plans, emission reduction goals were achieved, marked by consistent declines in industrial emissions of sulfur dioxide and chemical oxygen demand since 2006. These efforts have led to notable achievements in managing water basins and combating air pollution.

However, the environmental performance improvements driven by these effective regulations have come at a significant economic cost. Data from China's Ministry of Ecology and Environment reveal that China's total investment in pollution control escalated from around 16 billion USD in 2000 to nearly 135 billion USD in 2013 [3]. To comply with environmental regulations, some enterprises have resorted to reducing or limiting production as a means to curtail pollution emissions. For instance, He et al. [4] discovered that enterprises in areas with stringent environmental regulations, like upstream river regions, have adopted low water consumption technologies, which, while reducing pollution emissions, also lower productivity. Additionally, these enterprises have cut working hours, leading to significant reductions in total industrial output. Similar trends have been observed in various industry sectors. For example, following the 2017 introduction of the air pollution control plan for Beijing, Tianjin, Hebei, and neighboring areas, cities exceeding air quality index standards mandated pharmaceutical and pesticide enterprises to cease production during the winter heating season. This directive, coinciding with the domestic off-season for pesticide sales yet the peak production season, severely impacted enterprises in major provinces such as Hebei and Shandong, renowned for their pesticide formulation and active ingredient manufacturing.

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In summary, finding a development strategy that simultaneously enhances environmental and economic performance is both a longstanding academic inquiry and an urgent necessity for high-quality regional economic development. The ideas of New Structural Economics present a viable approach to tackle this dual-objective challenge. Adopting the lens of New Structural Economics, this paper zeroes in on the Yangtze River Economic Belt region. This study develops a congruence index for enterprises, measuring the alignment between local factor endowment structure and firm production input structure. Enterprises scoring higher on the congruence index are more adept at reducing their factor input costs. Such alignment signifies a closer match with the comparative advantages dictated by local factor endowments. This congruence not only directly elevates the economic performance of enterprises but also curtails their pollutant emissions, enhancing environmental outcomes. Consequently, it contributes significantly to realizing a dual victory in achieving both environmental and economic goals.

Utilizing a comprehensive dataset from the Chinese Industrial Enterprises Database, Environmental Survey and Reporting (ESR) database, and China City Statistical Yearbook, this paper constructs a micro-panel dataset of heavily polluting industrial enterprises in the Yangtze River Economic Belt from 1998 to 2012. The study investigates the impact of the congruence index on the environmental and economic performance of enterprises in this region. Regarding environmental performance, enterprises in the Yangtze River Economic Belt with higher congruence indices demonstrate improved outcomes. An increase of one standard deviation in the congruence index, on average, results in a 6.66% reduction in the industry's Chemical Oxygen Demand (COD) emissions and a 5.39% decrease in wastewater emissions per output value unit. Concerning economic performance, a one standard deviation increase in the congruence index yields notable benefits. It enhances the total industrial output value by approximately 8.09%, elevates main business income by around 8.3%, boosts operating profit by about 11.6%, increases employee numbers by roughly 10.5%, and raises total factor productivity by approximately 2.14%. These findings clearly demonstrate that a higher congruence index significantly bolsters the economic performance of enterprises. In the Yangtze River Economic Belt, enterprises with higher congruence indices, indicating a closer alignment with their city's factor endowment-derived comparative advantages, exhibit improvements in both economic and environmental performance. This alignment fosters high-quality regional economic development and achieves a synergistic win-win in environmental and economic performance.

2. Literature Review

This paper relates to the literature of studying the relationship between economic growth and environmental protection. A pivotal concept in this discourse is the Environmental Kuznets Curve (EKC) proposed by Kuznets [5], 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. 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. Historically, developed countries have grappled with similar challenges during their developmental stages.

Presently, nations primarily deploy external environmental regulations to mitigate environmental pollution issues. Pollution's strong negative externalities are multi-dimensional. Upstream enterprises' pollution burdens downstream areas [1,2]. Intergenerationally, one generation's pollution impacts the next. Across industries, industrial pollution diminishes the productivity of agricultural enterprises [6]. This indicates a market failure in self-regulating for optimal outcomes, underscoring the necessity of government intervention in environmental matters. Following the introduction of Scientific Outlook on Development in 2003, the Chinese government

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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.

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" [2,4], making it difficult to achieve the expected goals. For instance, under the "10th Five-Year Plan", local governments competing for tax revenue reduced environmental criteria to attract investment. This led to a "race to the bottom" in enforcing environmental standards [7–9], 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 [10]. For example, moving to the border of a downstream jurisdiction [2] or from the eastern coastal regions to the central and western regions [11]. 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 [3] and a decrease in enterprise productivity [4]. He et al. [4] 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. [12] 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.

3. Data Sources and Main Variables

The Yangtze River Economic Belt, chosen as the focus of this study, encompasses a significant portion of China, including major regions such as Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Yunnan, and Guizhou. Spanning 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) and upper reaches (Yunnan, Guizhou, Sichuan, and Chongqing) contributing 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's 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

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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.

3.1. 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 pertaining to 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 yields essential information about industrial enterprises in the region, including their establishment dates, sizes, locations, and types, along with economic performance metrics such as 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.

The post-matched panel data of enterprises in the Yangtze River Economic Belt, categorized by industry and regional distribution, is depicted 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 highlights 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 Ten 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

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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

3.2. 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. Our approach builds upon and enhances the national-level factor structure matching degree index developed by Ju et al. [12] in two significant ways. Firstly, we expand the measurement of the factor structure matching degree to the "city-industry-year" dimension. This expansion is vital, considering the substantial variation in factor endowments and industrial structures across different regions in China. Given the diversity of strategies employed by local governments in directing regional industrial upgrading, analyzing the congruence between local factor endowment structure and firm production input structure is essential. Secondly, our methodology involves assessing both the capital intensity of industries and the capital abundance of regions at a relative national level. This dual assessment provides a more nuanced and accurate depiction of an industry's alignment with the local factor structure. Additionally, to enhance the interpretability of the regression outcomes, the factor structure matching degree index has been standardized in this study.

The core explained variables in this paper are grouped into two main categories, representing environmental and economic performance of enterprises. For environmental performance, we focus on water pollution emissions with two indicators: COD emissions per unit of enterprise output and the volume of wastewater emissions per unit of enterprise output. COD is a measure of organic material content in water, with higher values indicating more severe organic pollution. Similarly, a higher volume of wastewater emissions suggests more intense pollution, pointing to poorer environmental performance. On the economic performance front, the paper examines several indicators including Industrial Total Output Value, Main Business Income, Operating Profit, Total Number of Employees, and Total Factor Productivity. These indicators collectively provide insights into the enterprise's production capacity, operating status, profitability, employment scale, and overall productivity efficiency. Detailed explanations and data sources for these variables are systematically presented in Table 2 of the paper, which is integral to the empirical section of the study.

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

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4. Empirical Results for the Environmental Performance

4.1. Baseline Regression

Table 3 displays the baseline regression results, elucidating 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, serving as a key indicator for water pollution emissions. Meanwhile, Columns (3) and (4) employ 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) of Table 3 present results without control variables, while Columns (2) and (4) incorporate a series of control variables, including the age of the enterprise, its ownership (state-owned or otherwise), size (measured by the number of employees), and the debt-to-asset ratio. Additionally, the regression model controls for city-by-year fixed effects and industry-by-year fixed effects, and standard errors are clustered at the city-industry level.

The results indicate that, irrespective of whether control variables are included, the congruence index significantly and negatively influences water pollution emissions per unit of output value. This outcome can be interpreted as follows: within the Yangtze River Economic Belt region, a higher alignment between local factor endowment structure and firm production input structure is associated with improved environmental performance. On average, an increase of one standard deviation in the congruence index corresponds to a 6.66% reduction in COD emissions per unit of industrial output value and a 5.39% decrease in wastewater emissions per unit of output value.

Table 3. the Congruence Index and Enterprise Environmental Performance: Baseline Regression.

	(1)	(2)	(3)	(4)
VARIABLES	*lnemicod_gdp*		*lnemiww_gdp*	
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 based on two-digit codes. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

There are some findings from the regression results for the control variables. Firstly, the age of an enterprise positively correlates with its pollution emission intensity, suggesting that newer enterprises tend to have better environmental performance. In terms of ownership, non-state-owned enterprises exhibit relatively superior environmental performance compared to state-owned ones. Additionally, a negative correlation is observed between the size of an enterprise and its pollution emission intensity, indicating that larger enterprises typically display more favorable environmental performance. In contrast, an enterprise's debt-to-asset ratio is positively correlated with pollution emission intensity. This implies that enterprises with higher debt-to-asset ratios, indicating elevated financial risk, may have less capacity or lower motivation to engage in energy-saving and pollution-reduction measures, thus exhibiting poorer environmental performance.

4.2. Robustness Check

To ensure the reliability of the basic regression results, the paper conducts four types of robustness tests. The first test involves utilizing alternate indicators of water pollution emissions, a key metric for assessing the environmental performance of enterprises in the Yangtze River Economic Belt. In local pollution prevention and control campaign, crucial emission monitoring indicators

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extend beyond the total wastewater emissions and COD used in the baseline regression. Ammonia Nitrogen (NH), a vital measure for nitrogenous organic matter pollution in water, is also included. While COD was established as a mandatory water pollution reduction indicator in the 11th Five-Year Plan for local assessment and promotion, NH ammonia nitrogen was incorporated as a key binding reduction indicator from the 12th Five-Year Plan onwards. Consequently, in Column (1) of Table 4, Ammonia Nitrogen (NH) per unit of enterprise output value is adopted as an alternate water pollution emission indicator in the robustness test. The results affirm the core conclusion's stability: the congruence index significantly and negatively impacts the intensity of NH ammonia nitrogen emissions per unit of output value among enterprises in the Yangtze River Economic Belt. A higher alignment between local factor endowment structure and firm production input structure is correlated with enhanced environmental performance.

Table 4. the Congruence Index and Enterprise Environmental Performance: Robustness Check.

	Different Indicators	**More Control Variables**		**Three-Digit Code Industry Classification**		**Pre-2010 Period**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	*lneminh_gdp*	*lnemicod_gdp*	*lnemiww_gdp*	*lnemicod_gdp*	*lnemiww_gdp*	*lnemicod_gdp*	*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.

The second robustness test involved adding more control variables to comprehensively account for various factors that could affect the pollution behavior of enterprises in the Yangtze River Economic Belt. In addition to the controls for enterprise age, ownership, and size as utilized in the basic regression, Columns (2) and (3) of Table 4 introduce further control variables. These added variables include the status of the enterprise as a Hong Kong, Macau, or Taiwan enterprise, its classification as a foreign-invested enterprise, the ratio of fixed assets to total assets (indicating operational flexibility and profitability), and the enterprise's own factor structure, specifically the capital-labor ratio. Upon integrating these additional control variables, the findings in Columns (2) and (3) of Table 4 consistently show that the coefficient for the congruence index remains significantly negative. This persistence confirms the primary conclusion: a higher congruence index markedly boosts the environmental performance of enterprises.

The third robustness test conducted in the study 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 4 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 in the study involves adjusting the regression year range to cover the period before 2010. This adjustment is made in light of the data used for enterprises in the Yangtze River Economic Belt, which are derived from the China Industrial Enterprise Database. Post-2010, the database underwent changes in the definition and selection criteria for "Enterprises above designated size", raising concerns about potential impacts on the estimation results. To mitigate these concerns, Columns (6) and (7) of Table 4 focus on observations from the pre-2010 period for the

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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 uniformly 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.

4.3. Analysis of Mechanisms

The analysis conducted so far, encompassing both the baseline regression and a comprehensive series of robustness tests, has firmly established the foundational conclusion: the congruence index positively influences the environmental performance of enterprises in the Yangtze River Economic Belt. The following section shifts focus to explore the mechanisms underpinning how the congruence index affects the intensity of water pollutant emissions by enterprises. We hypothesize that two primary mechanisms are instrumental in this process.

The first mechanism suggests that industrial enterprises in the Yangtze River Economic Belt with higher congruence index levels are more likely to adopt cleaner production technologies and energy-efficient structures. This hypothesis is grounded in the idea that enterprises with greater congruence between local factor endowment structure and firm production input structure are better aligned. Such alignment leads to reduced factor input costs, incentivizing these enterprises to embrace cleaner and more energy-efficient production methods, which ultimately result in a lower generation of pollutants. This mechanism has been empirically substantiated by Cai et al. [13]. Their research methodically differentiated between the “generation” and “treatment” of pollutants, delving into how the congruence index significantly lowers enterprise pollution emissions. They investigated whether the decrease in pollutant emissions per unit of enterprise output stemmed 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 enhancements 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, motivated, and effective emission reduction strategies for pollution reduction at the source signifies a more sustainable approach to development. This contrasts with 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 that exhibit a higher degree of 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 [12] and are less dependent on external subsidies, making them more capable and willing to allocate resources towards environmental protection facilities and equipment, thus achieving better environmental performance. Cai et al. [13] have empirically examined this mechanism in detail. Their approach

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involved 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.

5. Empirical Results for the Economic Performance

5.1. Baseline Regression

The previous section detailed the effects of factor structure compatibility on the environmental performance of enterprises. This section shifts the focus to the influence of the congruence index on 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 their economic consequences. While these regulations have significantly improved environmental performance, existing environmental economics literature often points to 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, exploring the role of the congruence index. It seeks to offer new insights into how both aspects can achieve a win-win situation rather than being a trade-off.

For instance, He et al. [4] 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 130 billion US dollars 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 will empirically explore the impact of the congruence index on the economic performance of industrial enterprises in the Yangtze River Economic Belt. It will also examine whether the observed improvements in environmental performance, due to the congruence index, are a result of economic sacrifices associated with scaled-back industrial operations.

Table 5 displays the empirical results from the regression analysis, with the economic performance of enterprises as the dependent variable and the congruence index as the independent variable. The study primarily utilized the following five measures to reflect the economic performance of the enterprises: (1) Total industrial output value, logarithmically transformed, to reflect the production capacity. (2) Main business revenue, logarithmically transformed, indicating the operating status. (3) Operating profit, logarithmically transformed, representing profitability. (4) Total number of employees, logarithmically transformed, indicating employment scale. (5) Total factor productivity, estimated using the LP method. The regression analysis reveals that a one standard deviation increase in the congruence index leads to approximately an 8.09% increase in industrial output value, about an 8.3% increase in main business revenue, around an 11.6% increase in operating profit, about 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 that the congruence index significantly boosts the economic performance of enterprises. Coupled with the earlier findings on environmental performance improvement due to the

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congruence index, the results imply that aligning local factor endowment structure and firm production input structure is crucial in achieving a win-win in both economic and environmental performance. This insight is especially pertinent as China strives for high-quality development and its "dual carbon goals", rendering these findings valuable for policy guidance. Furthermore, the analysis of control variables shows that enterprises with larger employment scales, lower debt-to-asset ratios, and shorter operational histories tend to have better economic performance.

Table 5. the Congruence Index and Enterprise Economic Performance: Baseline Regression.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	*lngdp*	*lnrevenue*	*lnprofit*	*lnemployee*	*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 based on two-digit codes. ***, **, and * denote significance levels at 1%, 5%, and 10%, respectively.

5.2. Robustness Check

The paper also executed thorough robustness checks on the basic regression results concerning the congruence index and enterprise economic performance. The first type of robustness regression involved incorporating additional control variables to more comprehensively account for factors influencing enterprise economic performance. Table 6, augmenting the control variables from the basic regression results, introduced extra controls such as: the status of the enterprise as from Hong Kong, Macao, or Taiwan, its ownership as a foreign enterprise, the ratio of fixed assets to total assets (indicating operational flexibility and profitability), and the enterprise's own factor structure (capital-labor ratio). The results with these new controls, presented in Panel A of Table 6, columns (1)-(5), confirm that the coefficient of the congruence index remains significantly negative. This reaffirms the core conclusion that the congruence index substantially enhances enterprise economic performance.

Table 6. the Congruence Index and Enterprise Economic Performance: Robustness Check.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	*lngdp*	*lnrevenue*	*lnprofit*	*lnemployee*	*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)

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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.

The second type of robustness test employed more granular industry classifications. Using a three-digit industry classification, the results in Panel B of Table 6, columns (1)-(5), consistently show that the congruence index significantly improves enterprise economic performance. This finding is maintained even under more detailed industry classification controls.

Lastly, the third type of robustness regression used sample data from years prior to 2010, addressing concerns about potential impacts on the estimation results due to changes in the selection criteria for large-scale enterprises in the China Industrial Enterprises Database post-2010. Utilizing pre-2010 observations for the regression samples in Panel C of Table 6, columns (1)-(5), the regression coefficient of the congruence index remains significantly positive. This robustly supports the conclusion that the congruence index significantly bolsters enterprise economic performance.

5.3. Analysis of Mechanisms

In exploring how the congruence index enhances the economic performance of enterprises in the Yangtze River Economic Belt, we identify two key mechanisms. The first is cost reduction: in line with New Structural Economics, stronger congruence between local factor endowment structure and firm production input structure leads to reduced factor input costs. The second mechanism is the promotion of research and development (R&D) and innovation: enterprises that are well-aligned with their comparative advantages, as dictated by local factor endowments, are more incentivized to engage in R&D activities. Benefiting from lower unit costs, these enterprises can significantly enhance their profitability through productivity gains following successful innovation, despite the fixed costs associated with R&D. This not only boosts their productivity but also their profitability, providing a strong motivation for pursuing R&D and innovation.

In their research, Lin et al. [14] conducted a detailed empirical validation of these two mechanisms. Firstly, to evaluate the impact of the congruence index on cost reduction, the study employed three cost metrics as dependent variables: annual total wages payable, labor costs (wages plus welfare expenses), 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. Secondly, in assessing the influence of the congruence index on enterprise R&D and innovation, the study analyzed four dependent variables: the R&D intensity of the enterprise (the ratio of R&D investment to sales), the proportion of new product output value, the number of patent applications, and the number of 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 suite of empirical analyses elucidates the precise mechanisms by which the congruence index boosts enterprise economic performance. When combined with the empirical findings from the first two sections of the study, it becomes clear that the congruence index not only drives enterprises to spontaneously enhance their environmental performance but also significantly bolsters their economic performance. This leads to high-quality development and a win-win in both economic and environmental aspects, underlining the multifaceted benefits of aligning industrial development with regional factor endowments.

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

This section undertakes an exploratory analysis on the influence of local government initiatives, such as the establishment of development zones and the selection of leading industries for clustering, on industrial agglomeration. Li and Shen [15] 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:

First, industrial agglomeration effectively lowers local transaction costs, thereby facilitating the transformation of comparative industrial advantages into competitive advantages [16]. 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 segment of the analysis, a sub-sample regression was conducted specifically on enterprises within the development zones of the Yangtze River Economic Belt. 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 7, 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 is 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 is significantly positive. This finding underscores that the congruence index substantially enhances both the environmental and economic performance of enterprises in the development zones.

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

	Environmental Performance				**Economic Performance**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	*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

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

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 regional 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.

7. Conclusions

The Yangtze River Economic Belt stands as a crucial catalyst for China's economic growth and a key battleground in its fight against pollution. The interplay of economic and environmental performance in this region is pivotal for China's pursuit of high-quality economic development and the attainment of its ambitious "dual carbon goals". Under the lens of New Structural Economics, this study focuses on the Yangtze River Economic Belt, constructing the congruence index to measure the alignment between local factor endowment structure and firm production input structure. This research explores how this alignment impacts the "environmental-economic" performance of enterprises in the area. The findings reveal that enterprises with a higher congruence index, indicating greater alignment with local factor endowments and comparative advantages, exhibit superior environmental and economic performance. Developing such industries not only capitalizes on their comparative advantages but also effectively drives the "environmental-economic" win-win scenario.

Through comprehensive empirical analysis and robustness tests, this paper arrives at several key conclusions:

- Environmental Performance: Enterprises in the Yangtze River Economic Belt with higher congruence index levels exhibit superior environmental performance. Specifically, a one standard deviation increase in the congruence index correlates with about a 6.66% reduction in COD emissions and a 5.39% decrease in wastewater emissions per unit of industrial output. This is attributed to the better alignment of these enterprises with the comparative advantages with local factor endowment within the Yangtze River Economic Belt. Such alignment facilitates reduced input costs, encouraging the adoption of cleaner production methods and the investment in environmental facilities, thereby diminishing pollutant generation at the source and enhancing overall environmental performance.
- Economic Performance: Similarly, enterprises with a higher congruence index also show enhanced economic performance. An increase of one standard deviation in the congruence index is associated with 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. The boost in economic performance is linked to reduced input costs and heightened motivation for R&D and innovation. Enterprises that are more congruent with their local factor endowments are incentivized to engage in R&D activities, enhancing their competitiveness and profitability.
- Impact of Industrial Agglomeration: The paper also reveals that industrial agglomeration amplifies the positive effects of the congruence index on "environment-economic" performance. A focused examination of enterprises in the development zones of the Yangtze River Economic Belt demonstrates that the congruence index significantly enhances both the environmental and economic performance of these enterprises. This underlines the critical role of industrial agglomeration in reinforcing the benefits of aligning industrial development with regional factor endowments.

The policy recommendations derived from this paper highlight that enhancing the congruence index, in contrast to relying solely on external environmental regulations, can significantly boost internal motivation within enterprises. This intrinsic motivation spurs the voluntary adoption of cleaner production technologies and increased investment in environmental facilities, steering

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enterprises towards a sustainable trajectory of high-quality development. Notably, this improvement in environmental performance is not achieved at the expense of economic growth. In fact, it can lead to advances in productivity, profitability, production scale, and other economic metrics, thereby facilitating the realization of the "environment-economic" win-win objective.

Accordingly, when local governments are attracting investment and formulating key industry policies, they should consider the alignment of potential industries with local factor endowments, rather than indiscriminately pursuing high-tech industries. In crafting industrial policies, a preference can be given to industries that match the comparative advantages defined by local factor endowments. For identifying pilot areas for specific industry development, regions where the congruence index between factor structure and industry capital-labor ratios is high should be prioritized.

Furthermore, considering that industrial agglomeration is a prominent feature and trend in the spatial distribution of China's manufacturing industry, it is beneficial to effectively guide the clustering of industries in development zones. Such clustering should align with local factor endowments, as it not only fosters economies of scale but also supports the achievement of environmental objectives alongside economic growth in the region.

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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