International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(4), 616-623.

The Dynamics of Environmental Resource Productivity: The Role of Economic Growth, Trade Openness, FDI, and Urbanization in China

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Received: 06 February 2025 **Accepted:** 27 May 2025 **DOI:** https://doi.org/10.32479/ijeep.19736

ABSTRACT

A research investigation uses Chinese provincial data from 2000 until 2024 to assess the environmental resource productivity (ERP) effects involving economic growth and trade openness alongside foreign direct investment (FDI) and urbanization. A composite measure for environmental resource productivity emerges through application of principal component analysis (PCA) among three key factors which are energy efficiency and material productivity combined with carbon emissions. Analysis using PARDL models demonstrates that investments from FDI together with GDP increases show a negative effect on ERP thus indicating that economic growth and foreign capital do not necessarily support better environmental outcomes. Both urban development patterns and increased trading links show positive relationships with ERP because they promote sustainable resource utilization methods. The co-integration test shows Shanghai along with Beijing Jiangsu Zhejiang Sichuan Henan Shandong follow a shape towards lasting balance however Guangdong moves apart demonstrating poor integration of its environmental and economic structures. FDI requires specific policy interventions which will help sustainability and support economic growth results that incorporate efficient resource usage. Policy makers need to establish tight environmental risk evaluation tools for FDI projects while adopting environmentally friendly trade policies and smart city development methods to create more effective ERP. Special policies must be designed to achieve economic realignment through industrial restructuring and regulatory improvements because Guangdong Province demonstrates distinctive patterns. This research delivers quantitative data to assist authorities in making choices about economic development versus environmental preservation so they can create sustainable development plans for all Chinese provinces.

Keywords: Environmental Resource Productivity, Economic Growth, Trade Openness, FDI, Urbanization
JEL Classifications: F6, O1, Q5

1. INTRODUCTION

During the past decades China achieved outstanding economic success by speeding up industrialization and transforming cities and expanding market freedom. The economic progress enables China to establish itself as a stronger player in worldwide economic operations. Rapid economic expansion in China has produced various important environmental issues. China needs smarter environmental resource management because its ongoing patterns of natural resource usage and carbon emissions continue to grow. The environmental emergency demands immediate planning adjustments which emphasize green development together with ecological sustainability. Assessing Environmental Resource Productivity (ERP) core determinants stands vital for China to transform its economy into an efficient and low-carbon environmentally-friendly system (Shaheen et al., 2022; Xin et al., 2023).

Organizations should use multiple interconnected methods to examine sustainable development because such measurements link economic advancement with environmental protection. Environmental Resource Productivity (ERP) functions as a necessary evaluation tool which examines how resources are utilized to create economic outcomes in detail (Schandl et al., 2024; Du et al., 2024). ERP measures how material and energy usage impact ecological integrity while being used to balance these factors (Bleischwitz, 2010). ERP features as a superior evaluation metric since it encompasses both economic progress and environmental protection simultaneously.

Green growth policies need ERP to function effectively as a tool for understanding sustainability in development processes (Shi et al., 2025; Shah et al., 2025). Green growth policies establish new solutions which separate economic development from the deterioration of environments and the exhaustion of resources. The model of ERP serves as a vital instrument which allows policy makers to determine if their implemented growth approaches maintain lasting sustainability (Chishti et al., 2023; Santoso et al., 2022). ERP delivers essential insights about the relationship between resource efficiency and environmental impact to show what economic outputs need to reach their lowest possible ecological cost.

In the case of China, ERP holds special relevance. China stands as a leading global economy in terms of rapid growth and industrial development while it needs to resolve the competition between environmental preservation and economic prosperity (Duan et al., 2024; Adanma and Ogunbiyi, 2024). China faces important challenges from its high industrial capacity and escalating energy requirements when managing resources in a sustainable way. The national benchmark of ERP serves as an important measure to evaluate resources usage efficiency in the country (Yuk et al., 2024). The assessment tool supports all stakeholders to understand China's ability to reduce environmental damage during its economic progress.

The measurement of ERP requires a Construction of a Total Index containing three critical elements: energy efficiency alongside material productivity and carbon emissions data. The index functions as a standard measure for observing sustainable resource management activities (Gutowski et al., 2013; Uzuner et al., 2025). The three essential metrics of resource performance include energy efficiency which measures production efficiency and material productivity which measures raw material utilization and carbon emissions which measure environmental effects. The ERP index unites three dimensions into a unified metric to measure sustainable development with comprehensive accuracy (Worrell et al., 2003; Kirikkaleli and Ali, 2024). Research about factors determining ERP at China's provincial level remains scant despite worldwide attention on environmental efficiency and green growth among scholarly circles. Existing academic research mainly investigates national data for assessing environmental performance but neglects to address the wide regional differences within China. China presents a wide spectrum of geographic and economic development across provinces because provinces differ substantially in their industrial production capability combined with resource presence and government oversight of operations together with their position in international trading systems. Difference between regions points towards different explanations behind the drivers of ERP.

Each province has its own manner of economic management alongside environmental rule enforcement and corporate attraction from foreign entities. The combination of coastal region industrial centers with increased FDI investment and enhanced infrastructure allows them to minimize energy usage while increasing output production efficiency and reducing pollution levels (Ting, 2022; Sriyanto et al., 2024). The provinces located within interior regions find it challenging to combine resource-intensive manufacturing with low carbon emissions and efficient resource utilization. Regional variances in the execution of policies and adoption of technology and environmental awareness levels affect the capability of sustainability initiatives to deliver their intended impact. The intricate patterns within regions can be hidden when analyzing at a national level which produces suggestions that may actually hurt provincial governments attempting to implement them (Zhao et al., 2025). A need exists to perform detailed analysis which properly depicts how economic development relates to environmental sustainability in specific conditions.

This research analyzes the provincial ERP data throughout the period of 2000–2024 in eight selected provinces of China to address this research gap. The research evaluates how economic growth together with trade openness and foreign direct investment (FDI) alongside urbanization influence ERP outputs in regional environments. Since these variables serve crucial functions in China's development plan they guide environmental outcome formation. Analysis of these variables as they affect ERP outcomes at provinces will enable policymakers to develop specific sustainability policies. This study investigates these factors in order to address major research gaps by providing localized proof of sustainable development pathways. The research results strengthen knowledge about factors that enable provinces to combine sustainable development objectives with economic growth. The projected research outcomes will assist policy makers in understanding how various growth and globalization levels affect ecological preservation in order to develop superior regional development approaches.

The study uses a quantitative empirical framework to evaluate a wide time span from 2000 to 2024 for its research goals. The building of an ERP composite index through PCA depends on energy efficiency metrics along with material productivity ratios and carbon emission data as core indicators. The established index reveals multiple elements describing ERP development patterns in provinces from different time periods. Businesses can use the developed ERP index as a tool for researching how ERP relates to its four main components: economic growth, trade activity, foreign direct investment and urbanization. This study investigates how economic expansion affects environmental performance by determining the resulting positive or negative ecological change. The study provides fundamental knowledge about investment planning together with urban development and trade policies that enhance ERP performance standards. The findings from this

research will help provincial policymakers create sustainable development plans to support provincial economic transformations toward green development throughout China.

2. LITERATURE REVIEW

Economic research in environmental science is exploring the dual relationship between economic development and natural conservation. Environmental Kuznets Curve emerged as a principal academic concept when Grossman and Krueger introduced it in 1995. The EKC model demonstrates that environmental pollutants behave in a way opposite to an upside-down U at different income levels since countries achieve economic strength which allows them to embrace environmentally friendly technology and regulatory systems. Scientists have conducted multiple studies about this assumption yet experimental findings are unclear regarding its validity in regional and sub-national environments. Economic development in China produces diverse environmental consequences across its various national regions. Zhang et al. (2017) together with Wang et al. (2022) discover that economic development boosted energy efficiency in some provinces yet several areas showed deteriorating material intake and escalating carbon output which demonstrates unequal regional benefits resulting from economic expansion. The research evidence shows why economic-environmental analysis requires examination at the provincial level because each region possesses distinct operational patterns.

The assessment of sustainable development requires Environmental Resource Productivity (ERP) because this metric brings together indicators about energy efficiency together with material productivity together with carbon emissions measurements. The actual relationship between economic growth and ERP shows distinct variations between different geographical areas. As such, a comprehensive assessment of ERP necessitates the consideration of localized economic, industrial, and institutional factors. Research on ERP as a unified index remains rare with many important gaps in knowledge about provincial level environmental performance from economic development.

International trade represents a primary factor which determines the state of environmental sustainability. The "pollution haven hypothesis" debates about trade liberalization link directly to the belief that developed nations move their polluting industries to developing countries that offer lax environmental standards (Cole and Elliott, 2005). Although this outcome creates localized environmental damage trading functions as a system through which environmentally friendly management methods and innovative technologies spread across different countries. Research conducted by Zhang et al. (2023) and Javed et al. (2024) demonstrates that trade improvements environmental efficiency through its delivery of green technologies and its enhancement of production quality standards. The Chinese provinces show different environmental impacts from trade because they possess varying levels of trade integration and industrial specialization together with different regulatory capacities. The complex region-specific trade patterns in China require localized research methods to understand how trade affects ERP through its influence on energy use and emission releases according to Ma et al. (2023) and Radulescu et al. (2024).

The environmental sustainability discourse gets significant impetus from Foreign Direct Investment (FDI). Environmental efficiency increases through FDI by bringing in modern technologies in combination with clean production procedures along with sustainable resource management approaches. Zarsky (1999) demonstrates FDI functions properly with environmental regulations to deliver technological exchanges and foster institutional capabilities. Evidence from Chinese empirical studies shows in He et al. (2021) that FDI improves industrial energy efficiency and emission reduction occurs mainly in provinces with robust technological infrastructure together with strong regulatory oversight. The positive environmental outcomes from foreign direct investment show variations among different regions thus establishing the requirement for an investigation at the provincial level. The extent to which Foreign Direct Investment aids in Environmental and Resource Preservation depends on the regional variations in technological absorption strength and industrial characteristics together with environmental management systems.

The process of becoming urban plays both positive and negative roles in achieving environmental sustainability goals. The energy efficiency of urban settings rises because large scale implementations are supported by developed public transit networks coupled with enhanced waste management systems. According to Glaeser and Khan (2010) densely populated areas promote efficient use of resources that lead to lower individual environmental effects. Unplanned rushed urban growth produces major environmental problems because it generates elevated energy requirements alongside air and water pollution that causes ecological damage. Seto et al. (2012) reveal that developing countries together with China are faced with rapid and extensive urban growth that surpasses the development of sustainable infrastructure systems. Diverse environmental effects from China's urbanization process emerged among provinces because of varying combinations between the capacity of urban development planning and local population densities together with governance capabilities. According to Li et al. (2020) research requires detailed analysis based on regional conditions to detect the intricate relationship between urban growth and environmental results.

2.1. Research Gap and Contribution

Previous research considered single aspects of environmental efficiency but ERP represents a composite metric which has received limited attention. The combination of multiple sustainable resource use dimensions results in environmental resource productivity as a better comprehensive efficiency measurement tool. The majority of related academic studies perform their assessments at the national scale but fail to recognize and evaluate the extensive provincial-level differences which characterize China due to its geographical and economic diversity. Environmental policies require unique approaches for the Chinese provinces since their levels of industrialization and trade intensity and FDI inflows and urbanization methods differ substantially.

A thorough ERP index consisting of energy efficiency alongside material productivity and carbon emissions indicators was created through Principal Component Analysis. The implemented methodological framework enables detailed assessments of

environmental efficiency performance in Chinese provinces at different locations. The researchers studied eight provinces through 2000 to 2024 to understand the effects of economic growth and trade and FDI and urbanization on environmental results performance.

The research makes significant progress through its detailed assessment of China's sub-national economic-environmental relationship. This study distinguishes itself from previous research by acknowledging that provinces behave differently since it considers their distinct developmental paths and policy approaches across regions. Such analysis provides an improved framework for understanding actual ERP dynamics that exists in specific contexts. Well-established policy interventions will receive guidance thanks to research findings that focus on better resource management and environmental governance for sustainable development promotion.

The research findings create useful directions for public officials to implement. The research helps create specific sustainability strategies by revealing the essential factors which impact ERP implementation across different Chinese provinces. Green FDI promotion combines with optimized trade structures and sustainable urbanization practices in these efforts. Analysis in this study fulfills critical gaps in the academic field and creates concrete methods to advance the ecological transformation of China.

3. DATA AND METHODOLOGY

The study has employed the eight provinces of China like Shanghai, Beijing, Guangdong, Jiangsu, Zhejiang, Sichuan, Henan and Shandong for the time period of 2000-2024. The aim of the study is construct the composite index for environment and resource productivity by using carbon emission, energy efficiency and material productivity. Principal component analysis (PCA) allows this study to create an ERP composite index for delivering empirical understanding about economic-environmental sustainability interconnections. The data for energy efficiency is collected from China Energy Statistical Yearbook, and China statistical yearbook on environment. This study is revealing ERP drivers to allow policymakers to balance economic development and ecological sustainability which supports China's nationwide environmental and development targets. The principal component analysis method is used to estimate the communalities and the results are reported in Table 1.

Table 1: Principal component analysis

Indicators	Initial	Extraction
Environmental productivity		
Carbon emission	1	0.711
Resource productivity		
Energy efficiency	1	0.627
Material productivity	1	0.796

The objective of the study can be shown in following mathematical model.

Environmental and resource productivity = f (Economic growth, Trade openness, Green FDI and urbanization)

$$ERP = f(GDP, TO, GFDI, URBN)$$

The description of variables is reported in Table 2.

4. EMPIRICAL RESULTS

The Pedroni co-integration test (Pedroni, 2004) is widely used in panel data analysis to determine whether a long-run relationship exists between variables. It is particularly useful when analyzing economic and environmental relationships across multiple regions or provinces, as in your study on economic growth, trade, FDI, and urbanization's impact on environmental resource productivity (ERP) in China. The results of Table 3 are rejecting the null hypothesis of no co-integration among the variables of the model.

4.1. Kao Residual Cointegration Test

Through the Kao Residual Co-integration Test (Kao, 1999) researchers verify whether panel data variables contain long-term equilibrium relations. When using the Engle-Granger two-step methodology researchers obtain residuals from panel regression then perform Augmented Dickey-Fuller (ADF) tests to determine stationary conditions. The result of stationarity among residuals indicates that variables maintain a long-term alignment which confirms their existence within a co-integration relationship (see Table 4).

The results of Kao test confirm the existence of co-integration relationships between economic growth alongside trade and FDI along with urbanization and Export-Related Productivity. Policies require economic factors to exert systematic influence over the long-term to achieve sustainability because these elements have an impact on ERP. Intervention policies should integrate development

Table 2: Description of variables

Variable	Description	Acronyms	Data source
Environmental and resource productivity	Composite index of energy efficiency, material productivity and carbon emission	ERP	Authors' estimation
Economic growth (%)	Annual percentage change in GDP of the province	GPD	China Statistical Yearbook
Trade openness (Exports + Imports as % of GDP)	Total exports and imports as a percentage of GDP	TO	China Statistical Yearbook
FDI (Billion USD)	Foreign direct investment specifically targeting green and sustainable projects	FDI	China Statistical Yearbook
Urbanization rate (%)	Proportion of urban population at year end by region	URBN	China Statistical Yearbook

Table 3: Pedroni residual cointegration test

Variable	Statistic	Prob.	Weighted statistic	Prob.
Panel v-statistic	−2.4660	0.9932	−2.6471	0.0196
Panel ρ-statistic	−1.2513	0.1054	−1.2085	0.0611
Panel PP-statistic	−7.0025	0.0000	−7.0125	0.0000
Panel ADF-statistic	−4.1443	0.0000	−4.0973	0.0000

Table 4: Kao residual Cointegration test

Augmented Dickey-Fuller test equation				
Variable	**Coefficient**	**Standard error**	**t-statistic**	**Prob.**
RESID(-1)	−1.2198	0.1039	−11.7415	0.0000*
D (RESID(-1))	0.1849	0.0729	2.5372	0.0120*
Kao Cointegration				
Variable	**t-statistic**		**Prob.**	
ADF	−2.7516		0.0030**	

*Rejecting the null hypothesis that the series are not stationary. **Rejecting the null hypothesis of no co-integration.

Table 5: Panel ARDL results

Variable	Coefficient	Standard error	t-statistic	Prob.*
Long run results				
FDI	−2.2875	0.2819	−8.1140	0.0001
URBN	0.0498	0.0098	5.0928	0.0023
TO	0.1132	0.0125	9.0467	0.0005
LGPD	−1.1787	0.2493	−4.7283	0.0038
Short run results				
COINTEQ01	−1.2795	0.3066	−4.1733	0.0001
D(ERP(-1))	0.5130	0.2584	1.9853	0.0517
D(ERP(-2))	0.3880	0.2314	1.6771	0.0987
D(ERP(-3))	0.3325	0.1630	2.0400	0.0458
D(FDI)	2.4241	0.7614	3.1837	0.0023
D(FDI(-1))	0.7715	0.5287	1.4592	0.1497
D(FDI(-2))	0.4896	0.5694	0.8599	0.3933
D(URBN)	−0.0455	0.0224	−2.0277	0.0470
D(URBN(-1))	0.0101	0.0330	0.3069	0.7600
D(URBN(-2))	−0.0305	0.0246	−1.2387	0.2203
D(TO)	−0.0912	0.0359	−2.5439	0.0136
D(TO(-1))	−0.0607	0.0254	−2.3888	0.0201
D(TO(-2))	0.0029	0.0233	0.1244	0.9014
D(LGPD)	1.7658	0.5929	2.9782	0.0042
D(LGPD(-1))	0.9590	0.6545	1.4653	0.1481
D(LGPD(-2))	0.7506	0.6324	1.1869	0.2399
C	28.4015	6.8204	4.1642	0.0001

projects with sustainable measures because the co-integration results support this multidimensional approach.

4.2. Panel Autoregressive Distributed Lag (PARDL) Model

Research using the panel Autoregressive Distributed Lag (ARDL) model demonstrates multiple economic and environmental relationships across the eight Chinese provinces as presented in Table 5. The research indicates that FDI and GDP show negative effects on the Environmental Resource Productivity (ERP) despite theoretical expectations (Amidi and Hishan, 2022; Jiao et al., 2024; Jiang, 2024). Some industrial activities within FDI operations produce environmental pressure since the goal of sustainable investment practices does not necessarily eliminate initial polluting activities until they become cleaner production methods. The fast economic expansion among provinces drives them to give preference to industrial development and monetary output over quick environmental management thus leading to escalated resource use and emissions despite their economic progress. The Environmental Kuznets Curve hypothesis states that environmental deterioration occurs first during developing stages of economic growth eventually leading to improved environmental outcomes at higher income levels (Mahmood et al., 2023; Hou et al., 2024). The environmental costs generated by economic growth in Chinese provinces could remain significant regardless of the current small scale of FDI investments.

The positive correlation between urbanization and trade openness shows environmental resource productivity improves as numbers of urban residents and deals with foreign countries increase (Cheng and Wang, 2023; Qi et al., 2024; Kayani et al., 2024). Strategic urban management enables better technical efficiency and infrastructure delivery as well as the adoption of greener technological systems in populous regions resulting

Table 6: Province-wise Cointegration results

Province	Coefficient	Standard error	t-statistic	Prob.*
Shanghai	−1.8870	0.0955	−19.7521	0.0003
Beijing	−2.3066	0.1594	−14.4663	0.0007
Guangdong	−0.0968	0.0487	−1.9852	0.1413
Jiangsu	−1.8105	0.1748	−10.3573	0.0019
Zhejiang	−0.4199	0.0081	−51.8522	0.000
Sichuan	−1.3780	0.2357	−5.8464	0.0100
Henan	−2.0010	0.0463	−43.1506	0.000
Shandong	−0.3360	0.0629	−5.34202	0.0128

in improved ERP values (Zheng et al., 2024; Wu et al., 2024). The openness of trading systems enables the adoption of green technologies and supports sustainable business operations and international environmental requirements which both minimize resource loss and improve environmental performance (Zhang et al., 2025; Kayani et al., 2024). Urbanization together with openness help provinces take advantage of advanced technology and policy initiatives that raise their ERP levels. Local strategies need development to achieve sustainability goals through appropriate foreign direct investment policies according to the research data. Economic objectives and urbanization patterns with trade directions enable the implementation of greener economic operations (Kayani et al., 2023; Wu and Zhang, 2021). Strategies implemented by policy-makers need to focus foreign direct investment towards sustainable projects while fostering economic growth through environmental regulations and efficiency programs for maximized ecological performance in these provinces.

4.3. Province-wise Convergence

A co-integration study of eight Chinese provinces has presented substantial proof about how steady economic relationships connect trade and FDI with urbanization and enterprise resource planning (ERP) throughout Chinese provincial zones. Table 6 indicated that the provinces of Shanghai and Beijing together with six others have achieved sustainable economic equilibrium through balanced environmental adjustments. Jiangsu and Zhejiang and Sichuan and Henan and Shandong alongside Beijing and Shanghai represent the provinces which have shown such convergence. The implementation of sustainable policies with economic growth and trade openness and urbanization practices will enhance ERP throughout these provinces (Cong et al., 2024; Munir and Ameer, 2018). These factors demonstrate consistent performance patterns over extended periods of time when used together. These systems maintain a self-correcting function which allows them to reach stable equilibrium conditions. Provincial initiatives toward sustainable development come through technology investments that use environmentally-friendly solutions and policy changes for trade conditions. Thus, ERP performs as predicted.

Wang et al., 2019; Yu and Zhao, 2020 demonstrate that the economic and environmental conditions in Guangdong province increasingly have fewer common factors year after year. The province maintains its deviation from equilibrium conditions. The statistical data demonstrates that Guangdong Province shows no direct relationship between environmental resource productivity and economic growth alongside trade transactions and foreign direct investment. Environmental resource productivity in Guangdong remains low because the province maintains an export-oriented economy supported by intensive resource industries as reported by Wu et al. (2018) and Jiang et al. (2019). The rapid urbanization in Guangdong Province potentially creates delays regarding the implementation of FDI into sustainable projects compared to the pace of sustainable infrastructure development and efficiency measures establishment. Emerging policy needs in Guangdong Province derive from the prominent differences between development goals and environmental protection priorities. Green investments require improved effectiveness which can be achieved through adopting environmentally friendly technologies in industrial and commercial systems and through strict environmental quality management systems. Long-term sustainability challenges that remain unaddressed in Guangdong province will stand in opposition to the existing positive progress achieved in another Chinese province.

5. CONCLUSION AND POLICY RECOMMENDATIONS

The principal component analysis (PCA) helped researchers determine how environmental resource productivity (ERP) levels in eight Chinese provinces change due to economic development and market availability and sustainable foreign direct investment and urban population dynamics. Since the research analyzed variables it was discovered that higher FDI levels and GDP rates generate lower equity ratio (ERP) indicators meaning economic growth enables industrial development yet produces no environmental efficiency improvements. The excessive resource utilization of economic growth within provinces combined with short-term projects pursued by foreign direct investment could help explain this trend. Modernization strategies implemented within ERP have shown progress from developments of open trade platforms and urban centers. The ability to conduct environmentally friendly operations across nations happens because both processes enable the transmission of technological data while requiring stringent environmental requirements. Resource productivity grows through well-managed urbanization because it enables the installation of contemporary infrastructure together with sustainable development methods and energy-efficient technologies.

Seven areas across Shanghai, Beijing, Jiangsu, Zhejiang, Sichuan, Shandong and Henan provinces achieved environmental economic stability during the analysis of provincial regions. Through economic activity these territories exhibit sustainable relations between human activities and their ecosystems. The trend of economic expansion in Guangdong province appears to operate against environmentally responsible business practices. The province faces sustainability challenges due to which Guangdong needs to transform its evidence-driven policies in order to achieve alignment between environmental objectives and economic results. The study demonstrates why nations need unique policies which unite economic development with sustainability. These policies will allow the effective use of foreign direct investment (FDI) while keeping urbanization advantages intact to boost ERP enhancement. Future political focus should direct officials toward creating strong policies to develop sustainable manufacturing together with

optimal trade and investment strategies for establishing enduring environmental stability with economic outcomes.

Policymakers need to create specific local plans which will improve environmental resource productivity without compromising economic growth. The adverse effect of FDI together with GDP demands attention at ensuring that genuine sustainable projects receive green investments rather than transitional or resource-intensive industries. Public authorities must strengthen their FDI environmental assessments by offering financial rewards to investments which establish clean energy fields and implement circular economy models along with environmentally friendly technological frameworks. The economic growth need to become independent from environmental deterioration through increased focus on resource-efficient industry sectors and tighter environmental control administered by strict regulations and investments into sustainable infrastructure. More market integration helps improve ERP because the exchange of technology along with adherence to international environmental requirements benefits the environment. The government ought to promote policies that create greener trading relationships and offer incentives for companies which adopt environmentally-friendly production practices. The positive relationship between urbanization and ERP calls for planning approaches that create intelligent cities alongside better sustainable transport systems and upgraded waste disposal methods in order to enhance urban sustainability benefits. Guangdong requires precise policy actions to alter its economic path toward sustainability through increased environmental regulation implementations along with stronger sustainability protocols in industrial complexes. All provinces need an integrated policy structure that embraces green funding methods together with environmentally responsible trade practices and sustainable urban development practices to achieve parallel economic development and environmental sustainability.

This research has made multiple valuable findings but researchers need to acknowledge several constraints. The research scope includes only eight provinces in China yet this selection does not fully represent all related economic and environmental patterns across the country. Additional provinces in the scope would help explain ERP variations within various economic-industrial environments throughout China. The study uses secondary data that depends on several environmental indicators which potentially show inconsistencies and measurement inaccuracies especially when measuring carbon emissions and material productivity. Research in the future should collect first-hand data and study businesses at specific levels to boost finding accuracy and precision.

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