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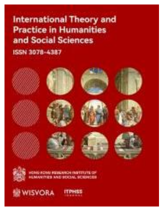

Analysis and Forecast of Green Development Level in Zhejiang Province

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Abstract

Based on data on energy consumption per unit of GDP in Zhejiang Province from 2000 to 2023, this paper constructs an exponential regression model to quantitatively analyze the evolution trend of green development. The results indicate that energy consumption per unit of GDP in Zhejiang Province exhibits a significant exponential downward trend, with a goodness of fit of 0.9573, reflecting a continuous improvement in energy utilization efficiency. Key policy milestones—such as the "Eight-Eight Strategy" implemented in 2003 and the energy-saving policies introduced during the 12th Five-Year Plan period—are highly consistent with stages of accelerated energy-intensity reduction, highlighting the strong role of policy interventions. Forecasting results suggest that energy consumption per unit of GDP will continue to decline in the future, although the rate of decline is expected to slow, indicating that improvements in energy efficiency are entering a stage of diminishing marginal returns. This study provides empirical evidence for evaluating green development performance in Zhejiang Province and offers quantitative support for future policy optimization.

1. Introduction

Under the national goals of carbon peaking and carbon neutrality, green and low-carbon transformation has become a strategic priority for China's economic and social development. As China shifts from high-speed growth to high-quality development, the traditional extensive growth model characterized by high energy consumption and high emissions has become increasingly unsustainable. Improving energy utilization efficiency is therefore widely recognized as a critical pathway to achieving coordinated economic growth, environmental protection, and resource conservation. As a core indicator of green development, energy consumption per unit of GDP not only reflects the efficiency of energy use in the production process but also captures the extent to which economic growth is decoupled from resource consumption and environmental pressure.

In recent years, the central government has intensively introduced a series of policies aimed at promoting green development and low-carbon transition. These policies cover a wide range of areas, including industrial restructuring, technological upgrading for energy efficiency, optimization of the energy mix, and the establishment of institutional mechanisms for energy conservation and emission reduction. Through policy instruments such as binding energy-saving targets, differentiated electricity pricing, fiscal incentives for green technologies, and strengthened environmental regulation, the government has provided clear and continuous guidance for green development practices at the provincial and local levels. Against this background, examining how energy utilization efficiency evolves over time and how it responds to policy interventions has become an important topic in both academic research and policy evaluation.

As one of China’s economically advanced provinces and a pioneer of reform and opening-up, Zhejiang Province represents a typical and exemplary case of green development. Zhejiang has long faced the dual constraints of limited energy resources and high economic density, which has forced the province to pursue a development path that emphasizes efficiency improvement rather than extensive expansion. Since the incorporation of “building an ecological province and developing a green Zhejiang” into the “Eight-Eight Strategy” in 2003, Zhejiang has gradually formed a relatively systematic policy framework covering energy conservation, industrial transformation, ecological governance, and clean energy utilization. Major initiatives, such as the “Thousand Villages Demonstration and Ten Thousand Villages Renovation” project, the “Five Water Governance” campaign, the “811 Environmental Protection Action,” and strict energy-saving assessments implemented during the 12th Five-Year Plan period, have continuously strengthened constraints on energy consumption and environmental performance. These measures have played an important role in accelerating industrial upgrading, promoting cleaner production, and improving overall energy utilization efficiency, enabling Zhejiang to maintain a leading position in national green development evaluations.

Despite Zhejiang’s notable achievements, existing studies on green development in the province and in China more broadly still exhibit several limitations. Many studies focus on qualitative analyses of policy design, ecological governance models, and green economic development paths, emphasizing institutional arrangements and governance experiences. While these studies provide valuable descriptive insights, quantitative examinations of long-term energy consumption trends and their dynamic evolution remain relatively limited. In particular, few studies systematically analyze how energy consumption per unit of GDP changes over an extended period and how key policy interventions correspond to different stages of energy efficiency improvement.

Moreover, against the background of continuous optimization of the energy mix and upgrading of industrial structure, the trajectory of energy consumption reduction is unlikely to be linear. Early-stage policy interventions and technological upgrades may generate rapid efficiency gains, while further improvements at later stages may exhibit diminishing marginal returns. However, existing empirical studies often rely on linear or static models, which may fail to capture the nonlinear characteristics of long-term green development processes. As a result, the stage-specific features, driving mechanisms, and future trends of the decline in energy consumption per unit of GDP have not yet been fully explored.

Accordingly, this paper employs data on energy consumption per unit of GDP in Zhejiang Province from 2000 to 2023 to construct an exponential regression model. By focusing on a long time span, this study aims to capture the nonlinear decay pattern of energy consumption and to reveal the dynamic evolution of energy utilization efficiency in the context of green development. Furthermore, by matching the estimated trends with key policy milestones — such as the implementation of the "Eight-Eight Strategy" and the energy-saving and emission-reduction policies during the 12th Five-Year Plan period—this paper provides a quantitative assessment of the role of policy interventions in shaping energy efficiency outcomes. On this basis, the model is further used to forecast future trends in energy consumption per unit of GDP, offering empirical evidence to support green development pathway selection and policy optimization at the provincial level.

2. Literature Review and Research Gap

Existing studies on green development and energy efficiency have mainly focused on three strands of literature. The first strand examines the long-term evolution of energy intensity and its convergence characteristics across regions or countries. Representative studies employ panel data models or convergence tests to explore whether regional energy efficiency differences are narrowing over time (Li et al., 2014; Zhang, 2015). These studies provide important insights into spatial heterogeneity but often emphasize cross-sectional comparisons rather than in-depth temporal dynamics within a single region.

The second strand of literature investigates the relationship between environmental regulation, policy interventions, and energy efficiency improvements. From the perspective of policy evaluation, scholars have analyzed how command-and-control regulations, market-based instruments, and incentive mechanisms affect firms' energy consumption behavior and technological upgrading (He et al., 2002; Stern, 2004; Yang, 2024). While these studies confirm the effectiveness of policy constraints in reducing energy intensity, many rely on discrete policy dummy variables or short-term policy shocks, making it difficult to capture the cumulative and nonlinear effects of long-term green development strategies.

The third strand focuses on modeling approaches for energy consumption forecasting. Traditional linear regression models, logarithmic specifications, and Environmental Kuznets Curve (EKC) frameworks are widely applied to analyze the relationship between economic growth and environmental indicators (Dong et al., 2013). However, such models often assume symmetric adjustment paths or turning-point effects, which may not adequately reflect the gradual deceleration of energy efficiency improvement observed in regions that have already entered a relatively advanced stage of green development.

Despite these contributions, several research gaps remain. First, relatively few studies systematically examine the long-term nonlinear trajectory of energy consumption per unit of GDP at the provincial level using a unified time-series framework. Second, existing research often separates policy analysis from quantitative trend modeling, lacking an integrated perspective that links policy milestones with dynamic changes in energy efficiency. Third, the diminishing marginal effects of green development policies in later stages are rarely discussed, particularly in economically advanced regions where energy efficiency has already reached a high baseline.

To address these gaps, this study focuses on Zhejiang Province as a representative case of advanced green development in China. By employing an exponential regression model based on long-term data from 2000 to 2023, this paper captures the nonlinear decay pattern of energy consumption per unit of GDP and systematically matches key policy interventions with changes in energy intensity. Furthermore, by incorporating forecasting analysis and policy mechanism discussion, this study provides a more comprehensive understanding of both historical evolution and future prospects of green development at the provincial level.

3. Methodology and Data Description

3.1 Data Sources and Variable Definition

The data used in this study are mainly obtained from the Zhejiang Statistical Yearbook (2000–2023), the Statistical Communiqués on National Economic and Social Development of Zhejiang Province, and official energy statistics released by the Zhejiang Provincial Energy Administration. All data are authoritative and officially verified, ensuring reliability and consistency.

Given that energy utilization efficiency is a core indicator of green development, energy consumption per unit of GDP (measured in tons of standard coal per 10,000 yuan) is selected as the dependent variable. This variable reflects changes in energy intensity during economic growth. The independent variable is time, represented as a continuous numerical variable corresponding to each year from 2000 to 2023, used to capture the dynamic evolution of energy intensity over time.

During data processing, consistency checks were conducted across different sources for the same year, with the final data released by the Zhejiang Statistical Bureau used as the benchmark in cases of minor discrepancies. Missing values for a small number of years were supplemented using linear interpolation to maintain the integrity of the time series. Finally, a natural logarithmic transformation was applied to energy consumption per unit of GDP to facilitate the linearization of the exponential regression model. Through these steps, a complete, continuous, and statistically consistent dataset for 2000–2023 was constructed, providing a solid foundation for subsequent modeling and analysis.

3.2 Model Specification

An examination of historical data from 2000 to 2023 reveals that energy consumption per unit of GDP in Zhejiang Province shows a persistent downward trend, characterized by a rapid decline in the early stage and a gradual slowdown in later periods. This nonlinear pattern is consistent with economic principles such as diminishing returns to technological progress and stabilization during industrial upgrading.

Accordingly, an exponential regression model is employed to capture the decay mechanism of energy consumption during the green development process:

$$y = ae^{bx}$$

where y denotes energy consumption per unit of GDP in year t, x is a constant representing the initial energy intensity level, and b is the exponential coefficient describing the rate of change over time. A negative value of b indicates an exponential decline in energy consumption, which aligns with the observed trend in Zhejiang Province.

To facilitate parameter estimation using linear regression techniques, the model is log-linearized by taking the natural logarithm of both sides:

$$lny = A + bx$$

3.3 Parameter Estimation Using Ordinary Least Squares

After linearizing the exponential model, the Ordinary Least Squares (OLS) method is applied to estimate the parameters. The transformed linear regression equation is expressed as:

$$Y_i = A + bx_i + \varepsilon_i$$

where ε_i represents the random error term. The objective of Ordinary Least Squares (OLS) is to minimize the residual sum of squares:

$$\sum_{i=1}^{n} (Y_i - A - bx_i)^2$$

By taking partial derivatives of the objective function with respect to the parameters and setting them equal to zero, the sample means of the independent and dependent variables can be obtained, and the estimator of the slope coefficient b is derived as:

$$b = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(Y_i - \overline{Y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

After estimating the slope coefficient b, the intercept term A can be obtained using the property that the regression line passes through the sample mean point

$$A = \overline{Y} - b\bar{x}$$

3.4 Model Diagnostics and Explanatory Power

The residual plot (Figure1) shows that residuals are randomly distributed around zero across different years, with no systematic upward or downward trend, no obvious cyclical fluctuations, and no structural deviations. This indicates the absence of significant heteroskedasticity and suggests that the residuals approximately satisfy the assumption of independent and identically distributed errors, meeting the prerequisites for OLS estimation.

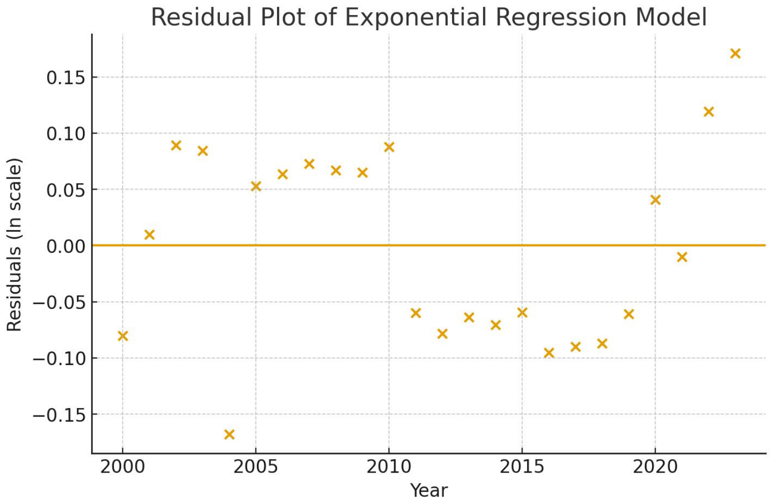

Figure 1. Residual Plot of the Exponential Regression Model

Moreover, residuals are evenly scattered above and below zero, implying that the model does not systematically overestimate or underestimate energy consumption per unit of GDP. Although slight deviations are observed in a few years (e.g., 2004 and 2022–2023), their magnitude is limited and does not undermine the overall goodness of fit.

3.5 Model Selection Rationale and Comparison

The choice of an appropriate functional form is crucial for accurately describing the evolution of energy consumption per unit of GDP. In the existing literature, several alternative modeling approaches are commonly adopted, including linear regression, logarithmic models, segmented trend models, and Environmental Kuznets Curve (EKC) specifications. Each of these approaches embodies different assumptions regarding the relationship between economic development and energy intensity.

Linear models assume a constant rate of change over time, which is suitable for short-term trend analysis but may fail to capture the nonlinear characteristics of long-term energy efficiency improvement. Logarithmic models allow for decreasing marginal effects but often lack a clear interpretation in terms of decay dynamics. EKC models, while widely used in environmental economics, primarily focus on identifying turning points between economic growth and environmental pressure, which may not be appropriate for regions where energy consumption per unit of GDP has been consistently declining without an observable rebound.

In contrast, the exponential regression model explicitly characterizes a decay process in which the rate of decline gradually slows over time. This feature is particularly consistent with the theoretical expectation of diminishing marginal returns to technological progress and structural adjustment in energy efficiency improvement. In the early stage of green development, policy interventions and technological upgrades can generate substantial efficiency gains. As the energy system becomes more optimized, further reductions in energy intensity require increasingly sophisticated technologies and institutional coordination, resulting in a slower decline rate.

From an empirical perspective, preliminary fitting results indicate that the exponential model achieves a higher goodness of fit compared to alternative linear or logarithmic specifications. More importantly, the estimated parameters have clear economic interpretations: the constant term reflects the initial level of energy intensity, while the exponential coefficient captures the long-term rate of efficiency improvement. Therefore, the exponential regression model is not only statistically appropriate but also theoretically consistent with the observed green development trajectory of Zhejiang Province.

4. Evolution of Green Development Level

4.1 Overall Trend of Energy Consumption per Unit of GDP

The time series of energy consumption per unit of GDP in Zhejiang Province from 2000 to 2023 demonstrates a continuous decline throughout the sample period, reflecting a long-term improvement in energy utilization efficiency. During the early stage (2000–2008), the decline was relatively steep, coinciding with accelerated industrial restructuring, the elimination of outdated production capacity, and large-scale energy-saving technological upgrades. In the mid-stage (2008 – 2016), strengthened binding targets for energy conservation and improvements in assessment systems further accelerated the reduction in energy intensity. In the later stage (after 2016), the decline rate slowed, indicating diminishing marginal returns from technological progress and structural optimization, as energy efficiency had already reached a relatively high level. Overall, Zhejiang's energy consumption per unit of GDP exhibits a typical pattern of "rapid decline in the early stage and gradual slowdown in the later stage," consistent with the transition from extensive to refined green development.

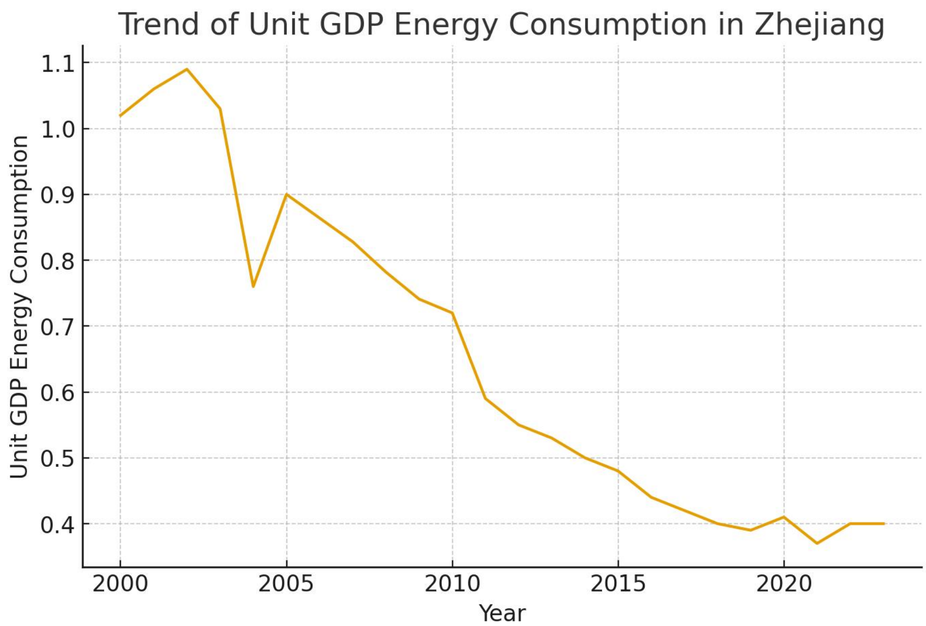

Figure 2. Energy Consumption per Unit of GDP

4.2 Analysis of Exponential Regression Results

Table 1 presents the estimation results of the exponential regression model. The coefficient of the time variable is −0.0516 and is statistically significant at the 1% level, indicating a significant exponential decline in energy consumption per unit of GDP over time. The coefficient of determination (R^2=0.946) suggests that the model explains the majority of temporal variation in energy intensity.

Table 1. Estimation Results of the Exponential Regression Model

Variable	**Coefficient Estimate**	**Standard Error**	**t-value**	**p-value**	**95% Confidence Interval**
Constant (A)	0.1516	0.0375	4.043	0.001	[0.074,0.229]

Time coefficient (b)	-0.0516	0.0026	-19.666	0.000	[-0.057,-0.046]

The negative exponential coefficient confirms that energy consumption declines exponentially over time, consistent with the observed green development trajectory in Zhejiang Province. The constant term corresponds closely to the initial energy intensity level. A comparison between the fitted curve and actual data points shows a high degree of overlap, demonstrating that the exponential model captures not only the overall decay trend but also subtle fluctuations in energy consumption.

4.3 Energy Consumption Forecast and Trend Interpretation

Based on the estimated exponential regression model, future trends in energy consumption per unit of GDP are projected (Figure 3). The forecast indicates that energy consumption will continue to decline along an exponential path, although the rate of decline will further slow, reflecting diminishing marginal improvements. This trend suggests that Zhejiang Province has entered a new stage of green development characterized by a shift from "speed-driven growth" to "quality-oriented improvement." Future gains in energy efficiency will increasingly depend on breakthroughs in core technologies, innovations in digital energy management, and further expansion of clean energy usage.

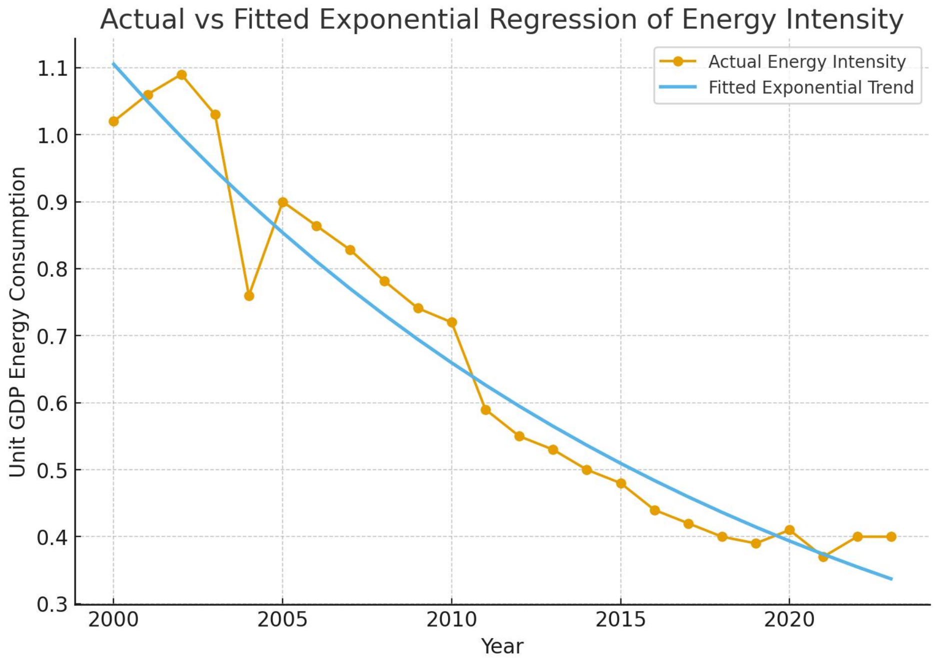

Figure 3. Exponential Regression Model

4.4 Forecast Uncertainty and Robustness Discussion

Although the exponential regression model provides a clear and stable forecasting path for future energy consumption per unit of GDP, it is necessary to acknowledge potential sources of uncertainty. Forecasting based on historical trends inherently assumes that the underlying structural conditions remain broadly stable. However, future energy efficiency improvement may be influenced by factors such as major technological breakthroughs, structural economic shocks, or changes in national and regional policy priorities.

First, technological uncertainty plays an important role. Breakthroughs in energy storage, hydrogen energy, or artificial intelligence–based energy management systems could significantly accelerate efficiency gains, leading to deviations from the projected trend. Conversely, delays in technological diffusion or constraints on capital investment may slow the pace of improvement.

Second, policy uncertainty may also affect the forecast. While Zhejiang Province has established a relatively mature green development framework, future policy adjustments—such as stricter carbon pricing mechanisms or expanded green finance support—could alter the trajectory of energy intensity reduction. In addition, external macroeconomic shocks may temporarily affect industrial structure and energy demand patterns.

Despite these uncertainties, the exponential forecast should be interpreted as a baseline scenario reflecting the continuation of existing development paths. The robustness of the model lies in its ability to capture the long-term nonlinear trend rather than short-term fluctuations. Therefore, the forecasting results provide a useful reference for medium- and long-term policy planning, while actual outcomes should be dynamically evaluated in conjunction with real-time policy and technological developments.

5. Policy Evolution and Mechanism Analysis

5.1 Policy Milestones and Temporal Matching with Energy Trends

From the long-term time series of energy consumption per unit of GDP in Zhejiang Province, the decline in energy intensity exhibits a clear stage-wise pattern that closely corresponds with the timing of major policy interventions. First, the formal introduction of the "Eight-Eight Strategy" in 2003, which emphasized "building an ecological province and developing a green Zhejiang," marked the institutionalization of green development in the province. During this period, Zhejiang significantly strengthened constraints on energy efficiency and accelerated the phase-out of high-energy-consuming and highly polluting industries, leading to the first pronounced decline in energy consumption per unit of GDP. This indicates that the early introduction of green development principles played a strong policy-guiding role.

Second, around 2011 represents another critical turning point in the decline of energy intensity. In this year, Zhejiang fully implemented the binding energy-saving and emission-reduction targets of the national 12th Five-Year Plan and introduced a series of supporting policies, including the Opinions on Energy Conservation in Zhejiang Province and the Assessment Measures for Energy-Saving Target Responsibility. These measures vigorously promoted energy efficiency improvements in industry, buildings, and the transportation sector, alongside optimization of the energy structure. As policy enforcement intensified, the rate of decline in energy consumption per unit of GDP further accelerated, forming a second phase of rapid reduction.

In addition, after 2016, Zhejiang accelerated the optimization of its clean energy layout and promoted the development of digital energy management platforms. Although energy consumption per unit of GDP continued to decline during this period, the downward trend became more stable, which is consistent with the broader transition of green development from a "scale expansion" phase to a "quality improvement" phase. Overall, the turning points in energy intensity decline are highly consistent with the timing of major policy implementations, underscoring the critical role of policy interventions in driving changes in energy utilization efficiency.

5.2 Policy Mechanisms: Industrial Structure, Energy Mix, and Technological Innovation

The decline in energy consumption in Zhejiang Province can be explained through three interrelated mechanisms: industrial structure optimization, energy structure adjustment, and energy-saving technological innovation.

First, in terms of industrial structure, Zhejiang has guided economic transformation from resource-intensive activities toward technology-intensive manufacturing and service-oriented sectors by implementing differential electricity pricing policies, restricting capacity expansion in high-energy-consuming industries, and accelerating the phase-out of outdated production capacity. The rapid development of high-tech manufacturing and the digital economy has significantly reduced energy intensity, making industrial upgrading a key driving force behind the decline in energy consumption.

Second, with respect to the energy structure, Zhejiang has actively promoted the utilization of clean energy sources, including wind power, photovoltaic power, and biomass energy, while accelerating the construction of natural gas pipeline networks and distributed energy projects. These efforts have substantially increased the share of non-fossil energy in the provincial energy supply. Notably, in 2023, the installed capacity of clean energy in Zhejiang exceeded that of coal-fired power generation for the first time, marking a fundamental shift in the energy structure from high-carbon to low-carbon. This transformation directly reduced both carbon emissions and energy consumption in the processes of energy production and final use.

Finally, in the area of technological innovation, Zhejiang has established a comprehensive system for energy-saving technological retrofitting, encouraging enterprises to adopt measures such as waste heat recovery, intelligent energy consumption monitoring systems, and the replacement of inefficient equipment with high-efficiency alternatives. Through fiscal subsidies and tax incentives, the application of energy-saving technologies has been widely expanded. In addition, leveraging its advantages in the digital economy, Zhejiang has promoted the development of online energy consumption monitoring platforms and digital energy management systems, enabling a shift from ex post energy management to real-time monitoring and thereby achieving sustained improvements in energy utilization efficiency.

5.3 Institutional Safeguards and Policy Implementation

In promoting green development, Zhejiang Province has established a multi-dimensional institutional support system encompassing regulatory frameworks, performance evaluation mechanisms, and fiscal incentives, thereby providing a stable institutional environment for the sustained decline in energy consumption.

With respect to regulatory frameworks, policy documents such as the Zhejiang Energy Conservation Regulation and the Implementation Plan for Ecological Civilization Construction in Zhejiang Province provide a clear and formalized institutional basis for energy-saving and emission-reduction activities undertaken by both local governments and enterprises. These regulations ensure that policy implementation is rule-based, legally grounded, and procedurally standardized.

Regarding performance evaluation mechanisms, Zhejiang has incorporated energy utilization efficiency indicators into the government performance appraisal system. Key energy-consuming entities are subject to energy consumption quota management, online energy monitoring, and annual performance assessments. Through hierarchical evaluations combined with reward-and-penalty schemes, policy enforcement has been significantly strengthened, enhancing compliance incentives and increasing the binding force of energy-saving regulations.

In terms of fiscal support, the provincial government has established dedicated funds for energy conservation, providing subsidies or interest discounts for energy-saving retrofitting projects, green manufacturing demonstration programs, and clean energy application initiatives. These financial incentives guide enterprises to continuously improve energy management practices and lower energy intensity. Complemented by supporting policies such as standardization initiatives, green factory cultivation programs, and strengthened energy supervision systems, Zhejiang has formed a coordinated mechanism characterized by government leadership, enterprise participation, and market support.

Overall, this multi-layered and systematic policy implementation pathway has enhanced the continuity and effectiveness of green development policies and has played a critical role in promoting the long-term and stable decline of energy consumption per unit of GDP in Zhejiang Province.

6. Discussion: Marginal Effects, Policy Limits, and Regional Implications

The empirical results of this study indicate that Zhejiang Province has achieved sustained and significant improvements in energy utilization efficiency over the past two decades. However, the observed deceleration in the decline of energy consumption per unit of GDP also suggests that green development has entered a stage characterized by diminishing marginal effects. This phenomenon has important implications for both policy design and regional development strategies.

From the perspective of marginal effects, early-stage green development policies tend to yield substantial efficiency gains by eliminating outdated production capacity and promoting basic technological upgrades. As these " low-hanging fruits " are gradually exhausted, further reductions in energy intensity increasingly depend on high-cost innovations and systemic coordination. This implies that future policy effectiveness will be less driven by scale expansion and more by quality improvement.

In terms of policy limits, the results suggest that administrative measures alone may face diminishing returns in advanced development stages. While regulatory constraints remain essential, excessive reliance on uniform standards may increase compliance costs without proportionate efficiency gains. Therefore, differentiated and market-oriented policy instruments—such as green finance, carbon trading, and digital energy management incentives—are likely to play a more prominent role in sustaining long-term improvements.

From a regional perspective, Zhejiang's experience provides valuable insights for other economically developed provinces. The exponential decline pattern observed in this study suggests that green development trajectories may exhibit similar nonlinear characteristics across regions, although the timing and pace may differ. For less developed regions, Zhejiang's early-stage policy measures remain highly relevant, while for advanced regions, the challenge lies in overcoming technological bottlenecks and institutional inertia.

Overall, this discussion highlights that green development is not a linear process but a dynamic transition characterized by changing marginal returns and policy priorities. Recognizing these characteristics is crucial for designing adaptive and forward-looking policy frameworks.

7.Conclusions and Policy Implications

This study employs an exponential regression model to conduct a systematic analysis of green development in Zhejiang Province based on data on energy consumption per unit of GDP from 2000 to 2023, and further explores the underlying mechanisms driving changes in energy intensity in conjunction with key policy milestones. The main conclusions are as follows.

First, energy consumption per unit of GDP in Zhejiang Province exhibits a significant exponential downward trend over the sample period, indicating a continuous improvement in energy utilization efficiency and reflecting the sustained deepening of green development principles within the process of economic growth. The goodness of fit of the exponential model reaches 0.9573, suggesting that the decline in energy intensity follows a stable long-term pattern with pronounced nonlinear characteristics.

Second, the stage-wise decline in energy consumption per unit of GDP closely corresponds with the timing of major policy implementations. The introduction of the "Eight-Eight Strategy" in 2003 initiated the institutionalization of green development and led to the first significant reduction in energy intensity. Subsequently, the energy-saving and emission-reduction policies implemented during the 12th Five-Year Plan period further strengthened energy constraints and accelerated the downward trend in energy consumption.

Third, through a combination of industrial structure upgrading, energy structure optimization, and energy-saving technological innovation, Zhejiang has formed a strong policy synergy that promotes improvements in energy utilization efficiency. This integrated approach has resulted in an efficient green development pathway characterized by institutional guidance and technological support.

Based on these findings, further improvements in green development and energy utilization efficiency in Zhejiang Province can be advanced through the following policy directions. First, continued efforts should be made to deepen industrial restructuring by promoting green transformation and digital upgrading of traditional manufacturing sectors, while accelerating the development of high-tech manufacturing and producer services in order to reduce overall energy intensity through structural change. Second, greater emphasis should be placed on expanding the deployment of clean energy by increasing the share of non-fossil energy sources—such as wind power, photovoltaic power, and nuclear energy—in the energy supply mix, improving distributed energy systems and energy storage infrastructure, and facilitating the transition toward a more low-carbon, secure, and efficient energy supply system. Third, greater support should be provided for the research, development, and diffusion of energy-saving technologies, including high-efficiency motor replacement, waste heat recovery, and intelligent energy consumption monitoring systems, while encouraging the application of digital technologies such as artificial intelligence and big data in energy management to overcome technological bottlenecks in energy efficiency improvement. Fourth, the institutional framework for energy conservation and emission reduction should be further strengthened by improving the dual control system for total energy consumption and energy intensity, enhancing monitoring and assessment of key energy-consuming industries and enterprises, and establishing performance-oriented incentive and constraint mechanisms to improve policy enforcement. Finally, while advancing green development, greater coordination across regions and industries should be promoted to build a multi-dimensional support system integrating green finance, green technologies, and green governance, thereby comprehensively enhancing the systemic coherence and long-term sustainability of green development.

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