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Industrial Pollution-Control Investment, Economic Development, and Tertiary-Sector Employment: Evidence from China's National Time-Series Data, 1998–2024

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Abstract: In the course of simultaneously advancing green transformation and the transition of employment toward the service sector, China has witnessed close interrelationships among environmental governance investment, the level of economic development, and the structure of service-sector employment. This study employs the national tertiary-sector employment share as the dependent variable, completed investment in industrial pollution control as the principal explanatory variable, and GDP per capita as a control variable. Stationarity tests, correlation analysis, and multiple regression estimation are conducted using EViews, while Newey–West heteroskedasticity- and autocorrelation-consistent standard errors are applied to correct for heteroskedasticity and serial correlation. The empirical results indicate that all three variables are integrated of order one, I(1), and that the model exhibits no multicollinearity. Both industrial pollution-control investment and GDP per capita significantly increase the tertiary-sector employment share, with economic development exerting a more pronounced effect on employment restructuring. Theoretically, this study develops an integrated time-series framework encompassing the three variables, quantifies the intensity of environmental regulation using a continuous measure of pollution-control investment, and clarifies the transmission mechanism through which economic growth facilitates the realization of green employment dividends. By addressing the limitations of existing research, which frequently examines individual variables in isolation and relies predominantly on regional samples, this study strengthens the body of macroeconomic empirical evidence concerning green development and labor allocation.

Keywords: Industrial Pollution Control; GDP per Capita; Tertiary-Sector Employment Share; Time-Series Analysis; Environmental Regulation

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1. Introduction

1.1 Research Background and Significance

As China's economy has shifted from high-speed growth to high-quality development, industrial pollution control, economic growth, and employment restructuring have become central to industrial transformation. Investment in industrial pollution control is an important instrument of environmental regulation: it compels traditionally energy-intensive industries to undertake green upgrading while also generating demand for environmental services. At the same time, sustained growth in GDP per capita provides a solid foundation for service-sector expansion and the reallocation of employment toward the tertiary sector. Against this background, examining the relationships among industrial pollution-control investment, GDP per capita, and the tertiary-sector employment share is important for understanding how green transformation can proceed in tandem with employment expansion. Existing studies generally examine the isolated effects of environmental regulation on either industrial structure or employment; empirical evidence on the joint evolution of all three variables remains limited. Using national time-series data for 1998–2024, this study estimates the effects of industrial pollution-control investment and GDP per capita on the tertiary-sector employment share. It thereby provides empirical evidence on the transmission mechanism from pollution control to industrial upgrading and employment restructuring, while offering policy implications for coordinating economic and environmental development and expanding high-quality employment.

1.2 Literature Review

Environmental regulation and the evolution of service-sector employment are central themes in research on green, high-quality development. Recent international scholarship has developed along two principal strands: the employment effects of environmental-governance investment and the mechanisms through which economic development drives the tertiarization of industry and employment.

The first strand focuses on the effects of environmental constraints on the sectoral reallocation of labor. Cui and Wan (2026) compare the heterogeneous employment effects of different environmental-policy instruments and identify industrial pollution-control investment as a quantitative measure of regulatory intensity. Such investment reduces employment in energy-intensive industries while generating demand for labor in environmental technology, environmental consulting, and other service activities, thereby providing theoretical support for the principal explanatory variable used in this study [1]. Using regional data, Qin et al. (2022) demonstrate that the employment effects of environmental governance are subject to threshold effects and that regional economic development moderates the influence of green policies on labor mobility [2]. Employing a long-horizon econometric model, Zhang (2023) identifies a long-run equilibrium relationship between green investment and service-sector employment; this empirical approach informs the time-series framework adopted here[3].

The second strand explains the tertiarization of employment from the perspective of economic growth. Peters et al. (2026) develop a cross-country framework of structural transformation and show that rising income per capita expands service-sector employment through two channels: the upgrading of household consumption and the increasing specialization of production [4]. Cross-country evidence provided by Fan et al. (2023) further confirms the positive effect of income on tertiary-sector employment and reveals marked differences in the magnitude of this effect across stages of development [5]. Zhang (2025) systematically reviews the full transmission mechanism through which economic development supports service-sector employment upgrading, providing a theoretical rationale for including GDP per capita as a control variable [6].

Nevertheless, the international literature leaves substantial scope for further research. Most empirical studies use cross-country or provincial panel data to investigate heterogeneity and generally estimate the employment effect of either environmental policy or economic development in isolation. Few studies incorporate industrial pollution-control investment, GDP per capita, and the tertiary-sector employment share into a unified long-horizon time-series framework. To address this gap, the present study constructs an econometric model using national time-series data for 1998–2024 and systematically identifies the long-run dynamic effects of the two principal determinants on the structure of service-sector employment.

2. Overview of the Research Context

2.1 National Context of Sectoral Employment and Environmental Governance

The period from 1998 to 2024 witnessed profound and simultaneous transformations in China's industrial structure, ecological-governance system, and allocation of labor. An extensive industrialization model gradually gave way to the concurrent advancement of green development and economic tertiarization. Industrial pollution-control investment, economic output per capita, and the service-sector employment share consequently evolved in a coordinated manner, reflecting the underlying relationships among environmental constraints, economic growth, and labor allocation. During the expansion of industrialization, rapid growth in heavy and chemical industries increased aggregate output but also produced accumulating ecological pressures. These pressures prompted the government to strengthen environmental controls and progressively expand funding for pollution abatement and environmental management in the industrial sector. As national income rose, household expenditure shifted increasingly toward consumer and professional services, generating large numbers of service-sector jobs. Labor continued to move out of traditional manufacturing, and employment in the tertiary sector expanded steadily, making the tertiarization of employment increasingly pronounced.

International empirical research supports this account. Wu et al. (2025) argue that sustained increases in industrial pollution-control investment promote successive rounds of green technological innovation, extend industrial value chains, and generate demand for labor in upstream and downstream producer services. Their findings substantiate, from the perspective of industrial transmission, the proposition that green investment improves the employment structure [7]. From the perspective of local public expenditure on environmental protection, Ma (2026) further explains that differences in the scale of pollution-control funding across localities directly affect the pace of industrial green upgrading and thereby alter regional patterns of labor mobility [8]. Xu and Zhao (2025) find that supporting environmental policies, including government environmental subsidies, accelerate the restructuring of industrial employment by directing labor from industry toward services through targeted financial support [9]. Related regional studies also indicate that the economic base is a critical determinant of policy implementation: more economically developed regions are better positioned to realize the employment dividends of green transformation.

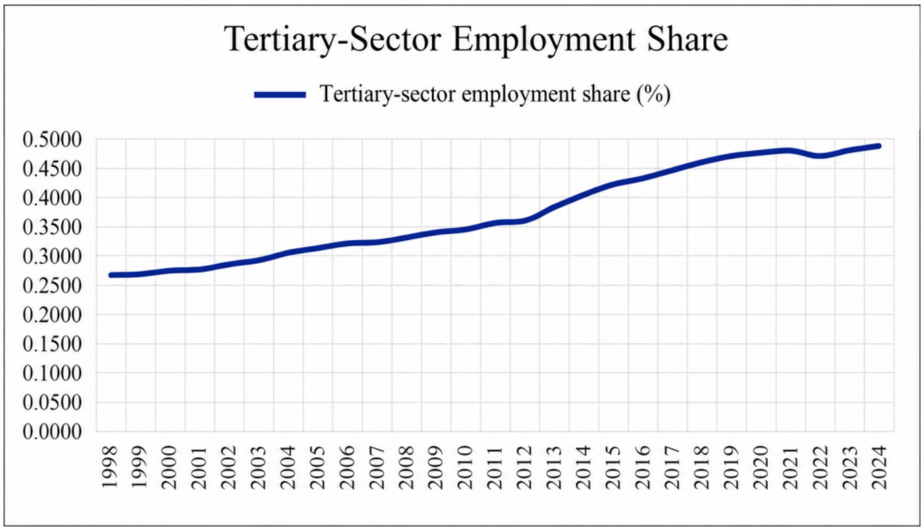
From a long-run perspective, economic growth strengthens the market foundation for service-sector development, while environmental regulation compels the industrial system to upgrade along greener lines. Together, these forces continuously expand the tertiary sector's capacity to absorb labor. Clarifying their dynamic interactions using long-horizon national data can inform the simultaneous pursuit of ecological protection, improvements in economic quality, and employment stability, while providing empirical support for macroeconomic policymaking.

2.2 Time-Series Characteristics of the Variables

2.2.1 Tertiary-Sector Employment Share

As shown in the figure, China's tertiary-sector employment share followed a sustained and stable upward trend from 1998 to 2024, rising from approximately 27% to nearly 49%, an increase of more than 20 percentage points. Between 1998 and 2012, the share rose from 27% to 36%, and the service sector gradually became an important source of employment. Growth accelerated after 2013. As the economy shifted toward a service-led structure, the service sector's capacity to absorb labor increased markedly, and it became China's largest employing sector. The series exhibits no pronounced cyclical decline and clearly illustrates the long-run transition of China's employment structure toward services.

Figure 1. Tertiary-sector employment share in China



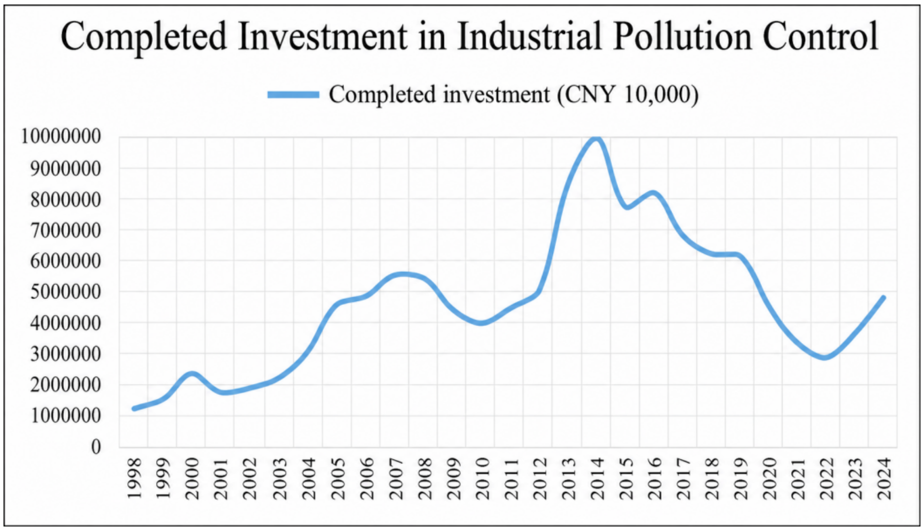
Source: Authors' calculations based on data from the National Bureau of Statistics of China.

2.2.2 Completed Investment in Industrial Pollution Control

As shown in the figure, completed investment in industrial pollution control in China increased over 1998–2024, albeit with substantial fluctuations, from approximately CNY 12 billion in 1998 to nearly CNY 50 billion in 2024. Between 1998 and

2008, investment expanded steadily as environmental awareness increased and policy priorities shifted. From 2009 to 2012, investment temporarily declined amid the business cycle and industrial restructuring before resuming its upward trajectory. Tighter environmental policies drove investment above CNY 100 billion in 2013–2014, producing a period-specific peak. After 2015, investment declined with industrial restructuring and advances in pollution-control technology, before rising again in 2023–2024 under China's carbon-peaking and carbon-neutrality goals. Overall, the fluctuations closely correspond to changes in environmental policy, industrial restructuring, and the stage of economic development.

Figure 2. Completed investment in industrial pollution control in China

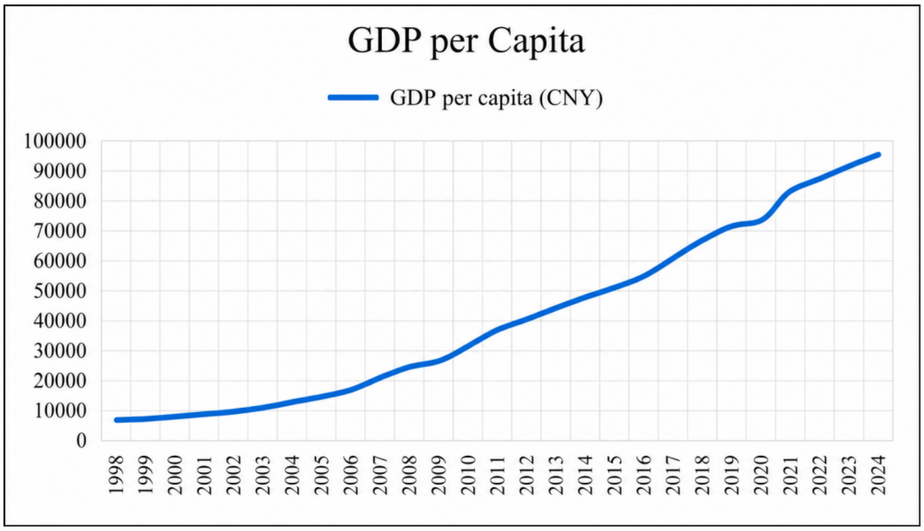


Source: Authors' calculations based on data from the National Bureau of Statistics of China.

2.2.3 GDP per Capita

As shown in the figure, China's GDP per capita increased rapidly and persistently from approximately CNY 6,800 in 1998 to nearly CNY 96,000 in 2024—more than a thirteenfold increase—and the series displays a pronounced stepwise upward pattern. The period from 1998 to 2006 was characterized by relatively slow growth, during which GDP per capita gradually surpassed CNY 10,000. From 2007 to 2012, the economy entered a phase of medium-to-high growth and GDP per capita rose rapidly. After 2013, growth moderated as China entered a stage of high-quality development, although the level of GDP per capita continued to rise. This expansion provided a strong economic foundation for service-sector development and industrial upgrading and was visibly associated with the rising tertiary-sector employment share.

Figure 3. GDP per capita in China



Source: Authors' calculations based on data from the National Bureau of Statistics of China.

3. Research Design and Empirical Analysis

3.1 Variable Selection and Data

The variables used in this study are China's tertiary-sector employment share, completed investment in industrial pollution control, and GDP per capita for 1998–2024. All data are obtained from publicly available statistics released by the National Bureau of Statistics of China.

Industrial pollution control and the level of economic development are important determinants of the sectoral employment structure. They directly affect both the scale and composition of tertiary-sector employment by compelling traditional industries to undertake green transformation and by enabling economic growth to expand and upgrade the service sector. Measures of structural upgrading commonly focus on changes in sectoral output shares. In selecting the dependent variable, however, this study also considers the persistent contribution of employment restructuring to high-quality economic development. Cui and Wan (2026) show that investment in industrial pollution control significantly influences regional employment structures by promoting cleaner production and generating demand for green services, thereby supporting the coordinated development of green industrial transformation and employment [1]. Wu et al. (2025) further note that the level of economic development conditions the employment effects of environmental policy. Higher GDP per capita promotes service-sector employment through consumption upgrading and a finer division of labor, thus providing the underlying economic foundation for the tertiarization of employment [7].

As China enters a stage of high-quality development, the country is at a critical juncture in both industrial green transformation and the high-quality development of services. Consistent with the coordinated evolution of industrial upgrading and employment restructuring, rising investment in industrial pollution control should increase the regional tertiary-sector employment share through a process in which pollution-control expenditure compels industrial transformation and expands employment in complementary services. Prior research indicates that, once an economy reaches a relatively advanced level of development, the focus of industrial development shifts from the expansion of industry alone toward the coordinated development of industry and services, thereby facilitating comprehensive employment restructuring. During 1998–2024, industrial pollution-control investment and GDP per capita both increased, while industrial green transformation and the expansion of service-sector employment proceeded jointly. The employment dividends of industrial restructuring were gradually realized, and services became the principal source of employment, accounting for nearly 49% of total employment by the end of 2024.

In light of these considerations and China's actual pattern of industrial development, this study does not use the tertiary sector's share of output as the sole measure of structural upgrading. Instead, it adopts the tertiary-sector employment share as the dependent variable. This indicator directly captures the tertiary sector's employment-absorption capacity and the extent of employment restructuring; its trend indicates the overall direction of industrial upgrading, while the magnitude of change reflects the pace of transformation. Drawing on prior research, authoritative statistics, and national industrial conditions, the analysis selects completed investment in industrial pollution control as the principal explanatory variable and GDP per capita as a control variable. Let Y denote the tertiary-sector employment share, X completed investment in industrial pollution control, and Z GDP per capita. All data processing and regression analyses are performed using EViews 13.0.

Table 1. Variable definitions

Variable role	Dependent variable	Principal explanatory variable	Control variable
Symbol	Y (%)	X (CNY 10,000)	Z (CNY)
Definition	Tertiary-sector employment share	Completed investment in industrial pollution control	GDP per capita
Interpretation	Employment in service-related industries as a share of total employment; measures the extent to which the employment structure has shifted toward services.	Total funds invested in industrial pollution prevention, pollution control, and environmental governance; directly reflects the intensity of regional environmental regulation and ecological governance.	Gross domestic product divided by the resident population; represents the overall level of regional economic development and material living standards.

Table 2. Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Standard deviation	Coefficient of variation
Y	0.3738	0.3568	0.4884	0.2670	0.0782	0.2092
X	4629372	4542586	9976511	1220461	2269821	0.4903
Z	40897.44	36855.00	95677.00	6914.000	29254.45	0.7153

Source: National Bureau of Statistics of China.

(1) The mean of Y is 0.3738, slightly above its median of 0.3568, indicating a mildly right-skewed distribution. The mean of X (4,629,372) is likewise slightly above its median (4,542,586), also indicating mild right skewness. The mean of Z (40,897.44) substantially exceeds its median (36,855.00), suggesting more pronounced right skewness. (2) The ranges of Y, X, and Z are 0.2214, 8,756,050, and 88,763.00, respectively. Y therefore exhibits the smallest range and the least absolute variation. The range of Z is smaller than that of X, indicating a more concentrated distribution in absolute terms. (3) The standard deviation of Y is 0.0782, the smallest among the three variables, whereas those of X and Z are 2,269,821 and 29,254.45, respectively, indicating greater absolute variability in X and Z. (4) The coefficients of variation are 0.2092 for Y, 0.4903 for X, and 0.7153 for Z. Y has the lowest coefficient of variation and, accordingly, the most representative mean. All three coefficients are below unity, suggesting relatively limited variation and generally stable distributions within the sample.

3.2 Analysis of Variable Trends

3.2.1 Time-Series Plots

Before specifying the regression model, the relationships among the variables are examined to assess the appropriateness of the model. The time-series plots generated in EViews are presented below.

Figure 4. Time-series plot of Y

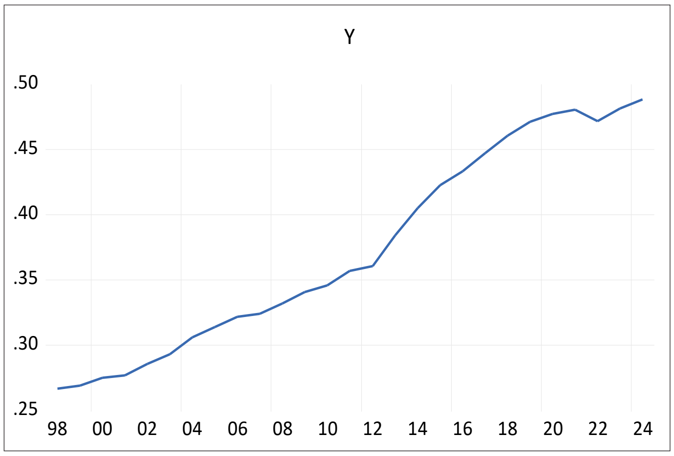


Figure 5. Time-series plot of X

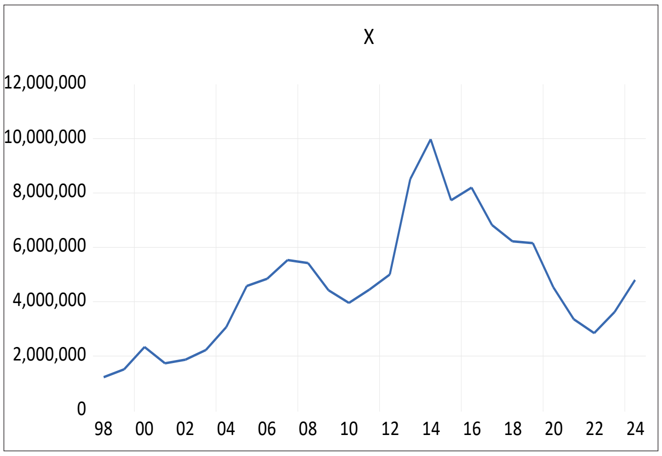


Figure 6. Time-series plot of Z

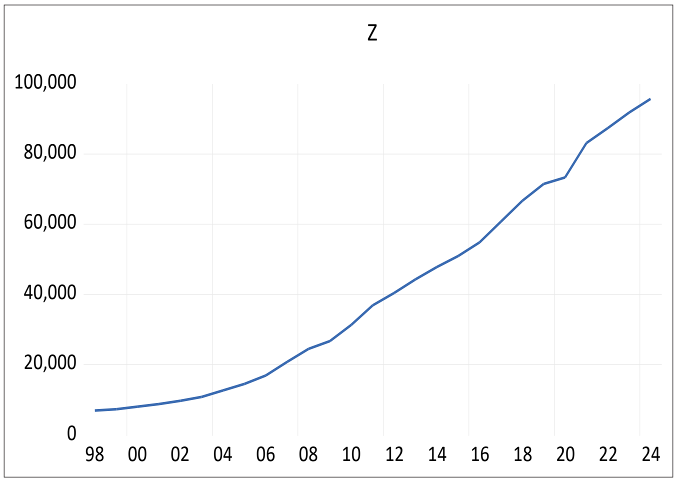


Figure 4 shows that the tertiary-sector employment share increased persistently over time. Although the series declined slightly in 2022, its overall upward trajectory remained stable. The pronounced time trend suggests that Y is nonstationary.

Figure 5 shows that completed investment in industrial pollution control fluctuated across phases: it increased steadily in the early years, reached a peak in 2014, subsequently declined, and recovered modestly toward the end of the sample. Because X exhibits a clear time-varying trend, it may be preliminarily classified as nonstationary.

Figure 6 shows that GDP per capita increased continuously and steadily over time, with growth accelerating in the later years. The pronounced upward time trend suggests that Z is nonstationary.

3.2.2 Stationarity Tests

Table 3. Augmented Dickey–Fuller test results

Variable	Test specification (C, T, L)	ADF statistic	p-value	Result
Y	(C, T, 2)	-2.602240	0.2823	Nonstationary
X	(C, T, 1)	-2.015554	0.5650	Nonstationary
Z	(C, T, 0)	-2.342068	0.3986	Nonstationary
D(Y)	(C, T, 0)	-3.310318	0.0876	Stationary*
D(X)	(C, T, 0)	-3.648020	0.0457	Stationary**
D(Z)	(C, T, 0)	-5.398868	0.0010	Stationary***

Note: Results are EViews output and are reported to four decimal places. The test specification (C, T, L) denotes the constant, time trend, and lag order, respectively. *, **, and *** indicate stationarity at the 10%, 5%, and 1% significance levels, respectively.

The p-values for Y, X, and Z are 0.2823, 0.5650, and 0.3986, respectively, all exceeding 0.05; therefore, the null hypothesis of a unit root cannot be rejected for any variable in levels. After first differencing, the p-values for D(Y), D(X), and D(Z) are 0.0876, 0.0457, and 0.0010, respectively. D(X) is stationary at the 5% level, D(Z) at the 1% level, and D(Y) at the 10% level. Thus, all three variables are integrated of order one, I(1), satisfying the stated requirements for subsequent modeling.

3.2.3 Scatterplots

Before specifying the regression model, the bivariate relationships among the variables are examined. The scatterplots generated in EViews are presented below.

Figure 7. Scatterplot of X and Y

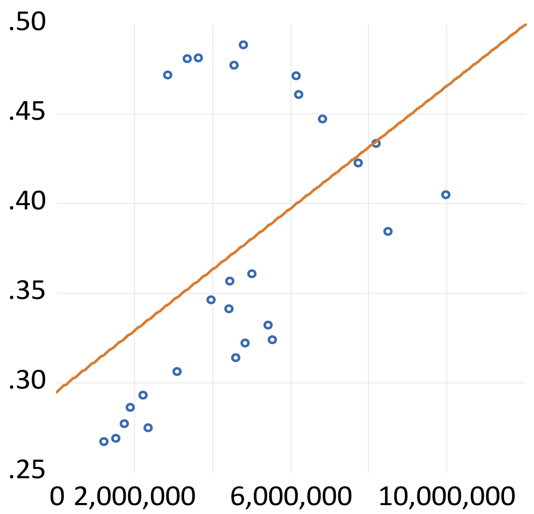


Figure 8. Scatterplot of Z and Y

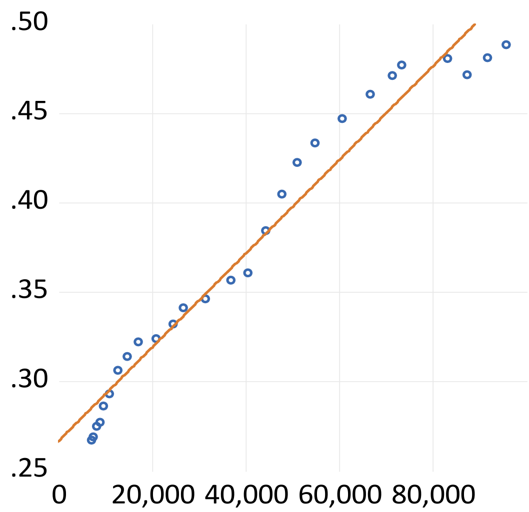


Figure 7 indicates that the observations are distributed broadly along the fitted line and that Y rises markedly with X, suggesting a strong positive linear association between the two variables.

Figure 8 indicates that the observations are tightly clustered around the fitted line and that Y increases steadily with Z, suggesting a statistically meaningful positive linear association between the two variables.

3.3 Regression Estimation and Diagnostic Testing

3.3.1 Baseline Model Specification

Based on the preceding analysis, the following multiple linear regression model is specified, with the tertiary-sector employment share (Y) as the dependent variable and completed investment in industrial pollution control (X) and GDP per capita (Z) as explanatory variables:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 Z_t + \mu_t$$

The model is estimated in EViews using X and Z as regressors. The results are reported below.

Table 4. Multiple regression results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.248964	0.005315	46.84386	0.0000
X	5.14E-09	1.07E-09	4.815454	0.0001
Z	2.47E-06	8.28E-08	29.82737	0.0000
R-squared	0.980161	Mean dependent var		0.373790
Adjusted R-squared	0.978508	S.D. dependent var		0.078167
S.E. of regression	0.011459	Akaike info criterion		-5.995570
Sum squared resid	0.003152	Schwarz criterion		-5.851588
Log likelihood	83.94020	Hannan-Quinn criter.		-5.952757
F-statistic	592.8791	Durbin-Watson stat		0.516400
Prob(F-statistic)	0.000000			

The p-value for X is 0.0001. Because $p < 0.001$, completed investment in industrial pollution control is positively and statistically associated with the tertiary-sector employment share at the 0.1% significance level. The p-value for Z is 0.0000, likewise indicating a positive and statistically significant association between GDP per capita and the tertiary-sector employment share at the 0.1% level. The intercept C is also statistically significant, with a p-value of 0.0000.

Overall, the model-level p-value is 0.0000, below 0.001, indicating that the regression is jointly significant. The R^2 and adjusted R^2 are 0.9802 and 0.9785, respectively, suggesting a very high goodness of fit and substantial explanatory power for changes in the tertiary-sector employment share. The estimated coefficients on both X and Z are positive, consistent with theoretical expectations: greater industrial pollution-control investment and higher GDP per capita are each associated with a significant increase in the tertiary-sector employment share.

3.3.2 Multicollinearity Test

Table 5. Multicollinearity test results

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.82E-05	5.807742	NA
X	1.14E-18	6.182956	1.162280
Z	6.86E-15	3.521181	1.162280

The centered variance inflation factors for X and Z are both 1.16, well below the conventional threshold of 10. The model therefore exhibits no serious multicollinearity; correlation between the explanatory variables has little effect on the regression results, and the parameter estimates are stable.

3.3.3 Heteroskedasticity Test

Table 6. White heteroskedasticity test results

Heteroskedasticity Test: White

Null hypothesis: Homoskedasticity

F-statistic	4.181896	Prob. F(5,21)	0.0086
Obs*R-squared	13.47084	Prob. Chi-Square(5)	0.0193
Scaled explained SS	7.385092	Prob. Chi-Square(5)	0.1935

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Sample: 1998 2024

Included observations: 27

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.68E-05	9.91E-05	0.270373	0.7895
X^2	-5.57E-18	4.72E-18	-1.179609	0.2513
X*Z	1.19E-15	6.57E-16	1.812466	0.0842
X	3.13E-11	5.16E-11	0.606898	0.5504
Z^2	4.84E-14	5.59E-14	0.865080	0.3968
Z	-6.91E-09	6.41E-09	-1.077396	0.2935

R-squared	0.498920	Mean dependent var	0.000117
Adjusted R-squared	0.379615	S.D. dependent var	0.000140
S.E. of regression	0.000110	Akaike info criterion	-15.19236
Sum squared resid	2.56E-07	Schwarz criterion	-14.90439
Log likelihood	211.0968	Hannan-Quinn criter.	-15.10673
F-statistic	4.181896	Durbin-Watson stat	1.926307
Prob(F-statistic)	0.008564		

The White test yields a p-value of 0.0086 for the F-statistic and 0.0193 for Obs*R-squared, both below 0.05. The null hypothesis of homoskedasticity is therefore rejected at the 5% significance level, indicating statistically significant heteroskedasticity. Newey–West robust standard errors are subsequently applied to mitigate the influence of heteroskedasticity on statistical inference.

3.3.4 Serial-Correlation Test

The Breusch–Godfrey LM test reported in Table 7 is used to determine whether the regression disturbances exhibit serial correlation up to the second order. The results are interpreted as follows.

Table 7. Breusch–Godfrey serial-correlation LM test results

Breusch-Godfrey Serial Correlation LM Test:

Null hypothesis: No serial correlation at up to 2 lags

F-statistic	17.41139	Prob. F(2,22)	0.0000
Obs*R-squared	16.54645	Prob. Chi-Square(2)	0.0003

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Sample: 1998 2024

Included observations: 27

Presample missing value lagged residuals set to zero.

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.001630	0.003519	-0.463140	0.6478
X	7.71E-10	7.86E-10	0.982067	0.3367
Z	-5.87E-08	6.21E-08	-0.944293	0.3553
RESID(-1)	1.046257	0.201109	5.202425	0.0000
RESID(-2)	-0.297159	0.236010	-1.259096	0.2212

R-squared	0.612831	Mean dependent var	5.87E-17
Adjusted R-squared	0.542437	S.D. dependent var	0.011010
S.E. of regression	0.007447	Akaike info criterion	-6.796317
Sum squared resid	0.001220	Schwarz criterion	-6.556347
Log likelihood	96.75028	Hannan-Quinn criter.	-6.724961
F-statistic	8.705696	Durbin-Watson stat	2.196004
Prob(F-statistic)	0.000227		

For two lags, the Breusch–Godfrey LM statistic, Obs×R^2, equals 16.54645, with a Chi-square(2) p-value of 0.0003, well below 0.01. The null hypothesis of no serial correlation is therefore rejected at the 1% level. The p-value associated with the F-statistic is 0.0000, corroborating this conclusion. The residuals from the multiple regression model consequently exhibit statistically significant second-order serial correlation. If ordinary least squares (OLS) were retained, the coefficient estimates would remain unbiased under the standard exogeneity assumptions but would no longer be efficient; the reliability of the t- and F-tests would decline, and parameter significance could be overstated. Taken together with the preceding heteroskedasticity test, the model exhibits both heteroskedasticity and serial correlation. Newey–West robust standard errors are therefore required to obtain reliable inference.

3.3.5 Model Correction

The diagnostic tests indicate that the regression model exhibits both serial correlation and heteroskedasticity. These problems compromise the efficiency of OLS estimation and the reliability of conventional significance tests. To address both issues and strengthen the credibility of the empirical conclusions, the baseline model is re-estimated using Newey–West heteroskedasticity- and autocorrelation-consistent standard errors.

Table 8. Newey–West robust estimation results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.248964	0.004682	53.17399	0.0000
X	5.14E-09	1.37E-09	3.742279	0.0010
Z	2.47E-06	1.36E-07	18.20933	0.0000
R-squared	0.980161	Mean dependent var		0.373790
Adjusted R-squared	0.978508	S.D. dependent var		0.078167
S.E. of regression	0.011459	Akaike info criterion		-5.995570
Sum squared resid	0.003152	Schwarz criterion		-5.851588
Log likelihood	83.94020	Hannan-Quinn criter.		-5.952757
F-statistic	592.8791	Durbin-Watson stat		0.516400
Prob(F-statistic)	0.000000	Wald F-statistic		268.4147
Prob(Wald F-statistic)	0.000000			

After applying Newey–West robust standard errors, the regression results are as follows.

The estimated coefficients on the intercept C, X, and Z are 0.248964, 5.14E−09, and 2.47E−06, respectively, and all corresponding p-values are below 0.01. Thus, at the 1% significance level, completed investment in industrial pollution control (X) and GDP per capita (Z) remain positively and significantly associated with the tertiary-sector employment share (Y).

The R^2 and adjusted R^2 are 0.9802 and 0.9785, respectively, indicating that the model continues to explain a substantial proportion of the variation in the dependent variable. The p-values for both the conventional F-statistic and the robust Wald F-statistic are 0.0000, so the model remains jointly significant. After the robust correction, the standard errors for X and Z increase and their t-statistics decline, as expected when correcting for heteroskedasticity and serial correlation. The adjusted results therefore provide more reliable parameter estimates and significance tests.

Accordingly, after accounting for heteroskedasticity and serial correlation, increases in industrial pollution-control investment and GDP per capita remain significantly associated with a higher tertiary-sector employment share, confirming the robustness of the results.

The estimated relationship between Y, X, and Z is therefore:

$$Y = 0.2490 + 5.14 \times 10^{-9}X + 2.47 \times 10^{-6}Z$$

$$(53.17) \qquad (3.74) \qquad (18.21)$$

$$R^2 = 0.9802,\ DW = 0.5164,\ F = 592.8791,\ Prob(F) = 0.0000$$

The coefficient on industrial pollution-control investment (X) is positive, indicating that a one-unit increase in X is associated, on average, with a 5.14×10^{-9} increase in the tertiary-sector employment share. The coefficient on GDP per capita (Z) is also positive: a CNY 1 increase in GDP per capita is associated with a 2.47×10^{-6} increase in the tertiary-sector employment share. Both signs conform to theoretical expectations. Greater investment in industrial pollution control promotes structural upgrading toward the tertiary sector, while higher GDP per capita supports service-sector development and thereby raises the tertiary-sector employment share. The R^2 of 0.9802 indicates that the model explains more than 98% of the variation in the dependent variable. The overall F-test has a p-value of 0.0000, rejecting the joint null that all slope coefficients equal zero at the 0.1% level and indicating a highly significant linear relationship. Following the Newey–West correction, the t-statistics for both explanatory variables remain significant, further supporting the stability of their estimated associations with the tertiary-sector employment share.

These results indicate that industrial pollution-control investment and GDP per capita are both important determinants of the tertiary-sector employment share, with the effect of GDP per capita exhibiting greater statistical strength ($t = 18.21$, p =

0.0000). Policy should therefore combine the pursuit of high-quality economic development and sustained growth in GDP per capita with greater investment in industrial pollution control. This coordinated approach can facilitate green industrial transformation and structural upgrading while steadily expanding the tertiary-sector employment share.

4. Conclusions and Implications

4.1 Main Findings

Using national time-series data for 1998–2024, this study incorporates completed investment in industrial pollution control, GDP per capita, and the tertiary-sector employment share into a unified analytical framework. A multiple regression model is estimated, with Newey–West robust standard errors applied to the parameter estimates, to examine systematically the long-run dynamic effects of environmental-governance investment and economic development on the tertiarization of employment. Three principal conclusions emerge.

First, the three indicators exhibit pronounced co-evolution over the sample period. The tertiary-sector employment share rises steadily over the long run; industrial pollution-control investment increases unevenly in response to shifts in environmental policy; and GDP per capita follows a persistent, stepwise upward trajectory. These time-series patterns provide descriptive evidence of an underlying relationship among green governance, economic expansion, and employment restructuring and support the empirical motivation of the study.

Second, industrial pollution-control investment and GDP per capita both have positive and statistically significant associations with the tertiary-sector employment share at the 1% level. Consumption upgrading and the increasing specialization of production associated with economic development continually expand the service sector's capacity to absorb labor, making economic development the more prominent driver of employment restructuring. Environmental expenditure in the industrial sector compels energy-intensive industries to undertake green upgrading and creates complementary service-sector jobs in environmental operations, maintenance, and consulting. These mechanisms continuously improve the sectoral allocation of labor and confirm that environmental regulation helps shape the employment structure.

Third, the diagnostic results support the reliability of the model within the stated specification. The original variables are integrated of order one, the explanatory variables exhibit no serious multicollinearity, and the model's heteroskedasticity and serial correlation are addressed using robust standard errors. The model has a high goodness of fit and can account for a substantial proportion of the long-run variation in China's tertiary-sector employment share.

4.2 Theoretical Contributions and Marginal Innovations

First, this study extends macro-level time-series research on the employment effects of environmental regulation. Existing studies generally rely on cross-country or provincial panel data and emphasize regional heterogeneity, while some international research focuses on the cross-regional relocation of polluting industries. Long-horizon analyses of interactions at the national level remain scarce. By integrating three key variables into a unified time-series analysis, this study addresses the limitations of examining each variable independently and adds long-run empirical evidence to the macroeconomic literature on green transformation and employment. This approach also complements the dynamic time-series framework proposed by Zhang (2023) [3].

Second, the study advances the empirical measurement of environmental regulation. Previous research frequently measures environmental constraints using indirect indicators, such as policy dummy variables or pollution charges. In contrast, this study employs a continuous measure of actual completed investment in industrial pollution control, allowing annual environmental-governance intensity to be represented by observed financial expenditure. It also traces the full transmission mechanism from environmental investment to service-sector employment. This measurement strategy can inform related empirical studies and supplements the macro-level time-series evidence on the employment effects of environmental-policy instruments reported by Cui and Wan (2026)[1].

Finally, the study elaborates the multilevel transmission mechanism associated with economic development. Existing research commonly includes GDP per capita only as a baseline control variable. The present analysis indicates that economic growth directly expands service-sector employment and strengthens the employment-structuring effects of environmental-governance policy, thereby establishing a comprehensive mechanism through which the economic base facilitates the realization of green employment dividends. This analysis enriches the theoretical understanding of the interdependence among green development, economic growth, and employment upgrading. It also accords with Peters et al. (2026), who emphasize income as a driver of service-led structural transformation, and provides a theoretical basis for distinguishing the employment effects of environmental policy across stages of development[4].

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No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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