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# The Influence of New-Quality Productivity on the Green Utilization Efficiency of Water Resources in Jiangxi Province

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**Abstract:**
*This study employs the entropy weight method to measure the level of new-quality productive forces across cities in Jiangxi Province. It uses the SBM-DEA approach to assess the green utilization efficiency of water resources. Based on these measurements, a dynamic panel data model is utilized to examine the impact of new-quality productive forces on the green utilization efficiency of water resources in various cities of Jiangxi Province. The findings indicate that Nanchang and Xinyu have the highest average values for the green utilization efficiency of water resources, whereas Jingdezhen, Ganzhou, and Pingxiang rank lowest. Overall, new-quality productive forces in the cities of Jiangxi Province contribute positively to enhancing the green utilization efficiency of water resources. Specifically, the new-quality labor force plays the most significant positive role, followed by the influence of new-quality labor objects.*

**Key words:**
*New-quality productivity; Green utilization efficiency of water resources; Jiangxi*

## 1. Introduction

With the rapid development of the economy and society, the issue of water scarcity has become increasingly prominent. Enhancing the efficiency of water resource utilization has thus become a critical component in achieving sustainable development. New-quality productivity, as a modern form of productivity centered on knowledge, technology, and information, offers innovative ideas and approaches for improving water resource utilization efficiency. As an important province in China's central region, enhancing water resource utilization efficiency in Jiangxi Province plays a vital role in promoting regional economic development and protecting the ecological environment. This study aims to investigate the influence mechanism through which new-quality productivity affects water resource utilization efficiency in Jiangxi Province, evaluate the contribution of each factor, and provide a theoretical foundation and practical guidance for the formulation of relevant policies.

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## 2.The Influence Mechanism of New Quality Productivity on the Green Utilization Efficiency of Water Resources

New-quality productivity refers to the enhancement of productivity achieved through means such as technological progress, management optimization, and efficient resource utilization. It not only encompasses traditional production factors but also highlights the critical role of knowledge, technology, and innovation in driving economic growth. New-quality productivity can influence the green utilization efficiency of water resources via the following mechanisms.

Firstly, new-quality productivity can enhance the green utilization efficiency of water resources by promoting green technological innovation. New-quality productivity provides guarantees for green technological innovation by stimulating green innovation vitality and broadening the prospects of green development. The driving effect of new-quality productivity on green technological innovation is market demand-oriented, fully mobilizing enterprises' enthusiasm for green technological innovation, strengthening their position as market innovation subjects, and significantly stimulating the vitality of green technological innovation. Green technological innovation enhances the green utilization efficiency of water resources by conserving water in production and daily life and reducing sewage discharge. On the one hand, the practical application of green technological innovation achievements optimizes production processes and techniques, conserves water resources, and reduces wastewater discharge and its ecological pollution at the source. On the other hand, green technological innovation effectively reduces enterprises' wastewater discharge costs, enhances their capacity to produce green products, enriches the green product ecosystem, and forms a virtuous cycle between green technological innovation and profitability for enterprises.

Secondly, new-quality productivity enhances the green utilization efficiency of water resources by promoting the upgrading of the industrial structure. Through technological innovation and the application of digital technology, new-quality productivity can elevate the technological level and product quality of traditional industries, strengthen industrial competitiveness, and drive the concentration of industrial structure toward advantageous industries, thereby facilitating the optimization and upgrading of the industrial structure. Additionally, new-quality productivity fosters integrated development across industries, giving rise to new industries, models, and business forms, promoting industrial diversification, and further driving the optimization and upgrading of the industrial structure. Moreover, new-quality productivity optimizes the spatial layout of industries, encouraging the concentration of industries in advantageous regions, which also contributes to the optimization and upgrading of the industrial structure. Furthermore, new-quality productivity promotes green industrial development, steering the industrial structure toward a low-carbon, environmentally friendly, and sustainable direction, thus enhancing the optimization and upgrading of the industrial structure. The upgrading of the local industrial structure improves input-output efficiency, reduces water resource consumption, and simultaneously decreases sewage discharge.

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# 3.Research Design

## *3.1Model*

Given the spatio-temporal dependence effect on the green utilization efficiency of urban water resources, we construct a dynamic panel data model to examine the impact of new-quality productivity on the green utilization efficiency of water resources in each prefecture-level city in Jiangxi Province. The following models are proposed:

$$WE_{it} = \alpha_0 + \alpha_1 WE_{it-1} + \alpha_2 NQ_{it} + \varphi C_{it} + \delta_i + \mu_t + C + \varepsilon_{it} \quad (1)$$

In the formula, i represents the city, t represents the year, WE is the green utilization efficiency of water resources in each city of Jiangxi Province, NE is the new quality productivity level of each city, C is the control variable, δ is the fixed effect of the city, μ is the fixed effect of the year, and ε is the random error term.

## *3.2Explanatory variable: New Quality Productivity level (NQ)*

Based on the connotation of new-quality productivity and drawing on relevant studies, this paper constructs an index system for measuring new-quality productivity (see Table 1). The measurement index system encompasses three core dimensions: new-quality labor force, new-quality labor materials, and new-quality labor objects. This system consists of ten first-level indicators and sixteen second-level indicators. On this basis, we employ the entropy weight method to calculate the level of new-quality productivity for each city.

*Table 1 Index System for New Quality Productivity*

| Dimension | Primary indicator | Secondary indicators |
|---|---|---|
| New-quality labor force | The number of employees in emerging industries | The total number of employees of listed companies in strategic emerging industries and future industries |
| | High-quality workers | Number of general higher education schools<br>Number of university students |
| | Income of workers | Average wage of employed workers |
| New-quality labor materials | Digtal infrastructure | Internet broadband access subscribers<br>Total telecommunication services<br>With or without a data trading platform, with a value of 1, without a value of 0 |
| | Production tool | Robot mounting density |
| New-quality labor objects | Ecological environment | Total investment in environmental pollution control<br>Non-hazardous treatment rate of domestic waste |
| | R&D Environment | Science expenditure as a share of local financial expenditure |
| | Technological innovation | Number of patents for inventions filed during the year<br>Number of utility model patents filed in the year |
| | Intelligent innovation | Number of artificial intelligence companies |
| | Green Innovation | Number of green inventions filed in the year<br>Number of green utility model patents filed in the year |

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### *3.3 Dependent variable: Water Resource Utilization Efficiency (WE)*

We employ the SBM-DEA method to measure the green utilization efficiency of water resources at the urban level. The DEA method is a non-parametric statistical evaluation model that does not require consideration of the functional relationships among various inputs and outputs. This approach avoids subjective biases, simplifies the calculation process, and reduces errors by eliminating the need for pre-estimated parameters. Moreover, it enables simultaneous analysis of multiple input and output indicators. The resulting analysis allows for performance optimization for each DMU and provides specific optimization recommendations based on the findings. Consequently, since its inception, the DEA method has garnered significant attention due to its unique advantages.

Suppose there is a production unit in the water resources production system, and each production unit has the same input and output indicators, including m input indicators and n output indicators. The output indicators include n1 expected output indicators and n2 non-expected output indicators. Then the input index value xk, the expected output index value yk, and the non-expected output index value zk of the Kth decision unit Tk are respectively expressed as:

$$\begin{cases} x_k = (x_{1k}, x_{2k}, \cdots x_{kn}) \in R^{m \times n} \\ y_k = (y_{1k}, y_{2k}, \cdots y_{kn} \in R^{n_1 \times n} \\ z_k = (z_{1k}, z_{2k}, \cdots z_{kn}) \in R^{n_2 \times n} \end{cases} \tag{2}$$

Based on the idea of constructing the SBM model containing non-expected outputs, it can be determined that the sample element set T is:

$$T = \left\{ (x, y, z) \mid x_l \geq X\lambda, y_l \geq Y\lambda, z_l \geq Z\lambda, \lambda \geq 0 \right\} \tag{3}$$

The traditional DEA model measures efficiency values under the assumption of variable returns to scale. However, in the traditional DEA model, the degree of returns to scale is exaggerated, which hinders the decomposition of scale efficiency. Consequently, the following SBM-DEA model incorporating non-desirable outputs is constructed:

$$\rho_0 = \min_{\lambda, s^+, s^-, s^{b-}} \frac{1 - \frac{1}{m}\sum_{k=1}^{m} \frac{s_k^-}{x_k}}{1 + \frac{1}{n_1 + n_2}\left(\sum_{j=1}^{n_1} \frac{s_j^+}{y_k} + \sum_{j=1}^{n_2} \frac{s_j^{z^-}}{z_k}\right)} \tag{4}$$

$$s.t. \begin{cases} \sum_{j=1}^{n} x_j \lambda_j + s^- = x_l \\ \sum_{j=1}^{n} y_j \lambda_j - s^+ = y_l \\ \sum_{j=1}^{n} y_j^{z^-} \lambda_j + s^{z-} = y^{z-} \\ \lambda_j \geq 0, s^- \geq 0, s^+ \geq 0, s^{z-} \geq 0 \end{cases} \tag{5}$$

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IIn Equation (4), the objective function $\rho_0$ represents the efficiency value of the production unit, xl represents the input index, $y_1$ represents the expected output index, and $z_1$ represents the non-expected output index; $s^-$ is the relaxation variable of the input indicator, $s^+$ is the relaxation variable of the expected output and $s^{z-}$ is the relaxation amount of the non-expected output. λ is the weight of the input factor. This model incorporates redundant variables into the objective function, takes into account the influence of external negative efficiency factors, optimizes the redundancy problem of input-output factors, and solves the efficiency measurement problem when there are non-expected outputs. However, when $\rho_0<1$, the model takes the farthest point on the envelope surface of the production unit as the standard, and the efficiency measurement result is relatively small. Therefore, it is necessary to further improve the model and adjust the production front from the farthest point to the most effective distance. The improved SBM-DEA model is as follows:

$$\begin{cases} \sum_{j\in R}^{n} y_j^{b^-}\lambda_j + s^{b-} = y^{b-} \\ \lambda_j \geq 0, s^- \geq 0, s^+ \geq 0, s^{b-} \geq 0 \end{cases} \quad (6)$$

$$s.t.\begin{cases} \sum_{j\in R}^{n} x_j\lambda_j + s^- = x_l \\ \sum_{j\in R}^{n} y_j\lambda_j - s^+ = y_l \\ \sum_{j\in R}^{n} y_j^{b^-}\lambda_j + s^{b-} = y^{b-} \\ \lambda_j \geq 0, s^- \geq 0, s^+ \geq 0, s^{b-} \geq 0 \end{cases} \quad (7)$$

The enhanced non-expected SBM-DEA model not only optimizes the objective function but also aligns more closely with the actual conditions of social production activities. Notably, the efficiency frontier of the production units remains consistent with that of the original model. To better reflect economic and social realities, we integrate the green influencing factor, specifically the environmental factor of sewage discharge volume, as a non-expected output in the evaluation of green resource utilization efficiency. In this context, total water consumption, labor, and capital are treated as inputs, GDP as the expected output, and sewage discharge volume as the non-expected output to assess the green utilization efficiency of water resources. Labor is quantified by the employed population in each city, while capital is measured using fixed asset investment in each region and year, with 2006 as the base period for deflation adjustment. Due to data limitations, industrial sewage discharge volume is used as a proxy for regional sewage discharge volume.

### *3.4 Control Variables*

Referring to the existing literature, we primarily control for the following variables: Degree of openness to the outside world (Open): This is measured as the ratio of a city's import and export values to its GDP. Financial Development Level (Fin): It is calculated as the ratio of the year-end loan balance of financial institutions in a city to its GDP. Economic Development Level (GDP): This is represented by the per capita GDP of each prefecture-level city, and its natural logarithm is used in the model. Industrial Structure (Ins): It is quantified as the ratio of the added value of the tertiary industry to the GDP of each city.

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### *3.5 Data*

Due to the limitations of data availability, this section selects the panel data of 11 prefecture-level cities in Jiangxi Province from 2006 to 2023. The main data are sourced from the "China Regional Economic Statistical Yearbook" "China City Statistical Yearbook", statistical yearbooks of various cities, and the database of the China Economic Information Network. Patent data is from the International Patent Office, robot installation density is from the International Federation of Robotics (IFR) alliance, and the number of artificial intelligence enterprises is from Qichacha.

## 4.Empirical results

### *4.1Results of the green utilization efficiency of water resources in each city of Jiangxi Province*

Based on the relevant statistical indicators for water resource utilization efficiency across various regions, in conjunction with the improved SBM-DEA model, the analysis was performed using MaxDEA 5.2 software, and the results are presented in Table 1. Table 1 displays the average green utilization efficiency of water resources for cities in Jiangxi Province from 2006 to 2023. Among these, Nanchang and Xinyu exhibit the highest average green utilization efficiency of water resources, whereas Jingdezhen, Ganzhou, and Pingxiang rank among the bottom three.

*Table 2. Average Value of Green Utilization Efficiency of Water*

| Cities | Average Value | Cities | Average Value |
|---|---|---|---|
| Nanchang | 0.887 | Fuzhou | 0.711 |
| Xinyu | 0.838 | Yingtan | 0.742 |
| Ganzhou | 0.681 | Shangrao | 0.748 |
| Jingdezhen | 0.699 | Jiujiang | 0.793 |
| Pingxiang | 0.656 | Yichun | 0.710 |
| Ji'an | 0.781 | | |

### *4.2 Empirical Results of the model*

Table 2 presents the regression results. Column (1) excludes the lag term of the dependent variable, Column (2) excludes the control variables, and Column (3) includes all variables. For the dynamic panel model, we employ the system generalized method of moments (GMM) for estimation. This approach effectively addresses potential endogeneity issues that may arise in dynamic panel models. As shown in the results, the coefficients of new quality productivity (NQ) are consistently positive and significant at the 1% level. This suggests that new quality productivity plays a crucial role in enhancing the green utilization efficiency of water resources in cities across Jiangxi Province. This effect is primarily attributed to the "green technological innovation effect" and the "industrial structure upgrading effect" associated with new quality productivity. By promoting green technological innovation and industrial structure upgrading, new quality productivity facilitates the rational use of water resources in Jiangxi's cities. It also improves the efficiency of labor and capital utilization while enabling the deployment of large-scale environmental protection facilities to reduce sewage

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discharge, thereby strengthening the green utilization efficiency of water resources.

*Table 3. Regression Results of the model*

| Variables | （1） | （2） | （3） |
|---|---|---|---|
| $WE_{it-1}$ | | 0.219*** | 0.230*** |
| | | （3.904） | （3.895） |
| NQ | 0.166*** | 0.163*** | 0.158*** |
| | （6.945） | （6.472） | （6.484） |
| Trade | 0.085 | | 0.065 |
| | （1.301） | | （0.944） |
| Fin | 0.024*** | | 0.033*** |
| | （4.643） | | （5.278） |
| GDP | 0.144*** | | 0.171*** |
| | （4.365） | | （4.162） |
| IND | 0.067*** | | 0.112*** |
| | （5.299） | | （4.492） |
| Year fixed effect | Y | Y | Y |
| City fixed effect | Y | Y | Y |
| Sargan test | 11.3 | 13.2 | 14.5 |
| | [1.000] | [1.000] | [1.000] |
| AR(1) | -3.04 | -2.68 | -3.17 |
| | [0.003] | [0.008] | [0.004] |
| AR(2) | 1.76 | 1.39 | 1.29 |
| | [0.068] | [0.023] | [0.041] |
| N | 187 | 187 | 187 |

Note: The value in parentheses is the t value, and the value in square parentheses is the p value. *, **, *** respectively indicate significance at the 10%,5%, and 1% levels.

By observing the coefficients of the control variables, it is found that the level of economic development (GDP) has a significant positive effect on the green utilization efficiency of regional water resources. Although the level of economic development has positive and negative effects on the green utilization efficiency of water resources. The negative effect is that the increase in per capita GDP requires the consumption of more industrial and agricultural products. The production of these products needs to be supported by more energy and water consumption, and at the same time, it will also bring more environmental pollution, thereby harming the green utilization efficiency of water resources. The positive effect is that the economic development level will prompt the government and individuals to have higher requirements for the ecological environment. The government may have a stronger constraint force on the consumption and pollution of water resources while individuals have a stronger awareness of the protection and rational utilization of water resources, which is conducive to improving the green utilization efficiency of water resources. At present, the overall economic development level of Jiangxi Province is at a stage where the positive effect is greater than the negative effect, and it generally shows a significant positive effect. The Financial Development (Fin) coefficient and the Industrial Structure (IND) coefficient are significantly positive, indicating that the higher the level of urban financial development and the higher the proportion of the service industry, the more prominent the promoting effect on the green utilization efficiency of water resources. The coefficient of Trade openness

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is not significant. This is mainly because the degree of trade openness has both positive and negative effects on the efficiency of water resource utilization. The positive and negative effects offset each other, thus showing an insignificant comprehensive effect.

### *4.3 Test Results by Dimensions*

We re-examined the new quality productivity across three dimensions: new-quality labor force, new-quality labor materials, and new-quality labor objects. The results are presented in Table 3. All three dimensions have positively contributed to the green utilization efficiency of water resources in various cities of Jiangxi Province. Specifically, the new-quality labor force has the most significant positive impact, followed by the new-quality labor objects, while the new-quality labor materials has the least effect. This suggests that in the development of new-quality productivity, the new-quality labor force plays the most critical role.

*Table4 Test results by dimensions*

| Variables | New-quality labor force | New-quality labor materials | new-quality labor objects |
|---|---|---|---|
| $WE_{it-1}$ | 0.294*** | 0.244*** | 0.267*** |
| | （4.148） | （3.973） | （3.159） |
| NQ | 0.162*** | 0.126*** | 0.150*** |
| | （6.035） | （5.430） | （6.621） |
| Trade | 0.078 | 0.063 | 0.071 |
| | （0.891） | （1.122） | （1.489） |
| Fin | 0.137*** | 0.092*** | 0.077*** |
| | （6.894） | （6.535） | （4.428） |
| GDP | 0.166*** | 0.141*** | 0.116 |
| | （5.845） | （4.487） | （0.994） |
| IND | 0.164*** | 0.183*** | 0.175*** |
| | （4.531） | （4.843） | （4.369） |
| Year fixed effect | Y | Y | Y |
| City fixed effect | Y | Y | Y |
| Sargan test | 12.9 | 14.8 | 13.1 |
| | [1.000] | [1.000] | [1.000] |
| AR(1) | -3.48 | -3.04 | -3.24 |
| | [0.011] | [0.009] | [0.014] |
| AR(2) | 1.35 | 1.37 | 1.26 |
| | [0.065] | [0.030] | [0.039] |
| N | 187 | 187 | 187 |

Note: The value in parentheses is the t value, and the value in square parentheses is the p value. *, **, *** respectively indicate significance at the 10%,5%, and 1% levels.

## 5.Conclusions and Policy Implications

### *5.1 Conclusions*

Based on the measurement of the new quality productivity level of various cities in Jiangxi Province by us-

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ing the entropy weight method and the measurement of the green utilization efficiency of water resources by using the SBM-DEA method, this paper uses the dynamic panel data model to test the influence effect of the new quality productivity of various cities in Jiangxi Province on the green utilization efficiency of water resources. It was found that the average green utilization efficiency of water resources in Nanchang and Xinyu was among the top, while the green utilization efficiency of water resources in Jingdezhen, Ganzhou, and Pingxiang ranked among the bottom three. Overall, the new quality productivity in various cities of Jiangxi Province has promoted the improvement of the green utilization efficiency of water resources. Comparatively speaking, the positive role played by the new quality labor force is the greatest, followed by that of the new quality labor objects.

### *5.2Policy Implications*

This article draws the following policy implications: (1) Governments, enterprises, and individuals should prioritize establishing the concepts of water conservation, energy conservation, and environmental protection. These green and ecological development concepts should be deeply ingrained in people's minds and implemented in practice to enhance the green utilization efficiency of water resources and promote high-quality economic development. During import and export processes, all regions should strictly control the export of "three high" products—those that are highly water-consuming, energy-consuming, and polluting during production—and appropriately increase the import of such products to mitigate their negative impact on domestic water resources, energy, and the environment. (2) Accelerate the construction of a modern industrial system and improve the mechanism for fostering new quality productive forces. Fully leverage the supporting or service functions of governments, research institutions, universities, and enterprises for modern industries, and collaboratively build a modern industrial system. By applying digital and intelligent technologies, vigorously develop advanced manufacturing, cultivate advanced manufacturing clusters, and transform and upgrade traditional manufacturing. (3) In the development of new-quality productive forces, particular emphasis should be placed on cultivating a new-quality labor force. The new type of labor force is characterized by the iterative upgrading of knowledge-based, intelligent, and digitalized labor capabilities, with scientific and technological literacy, professional spirit, and innovative consciousness as its core attributes. It exhibits a significant advantage in high labor productivity and represents advanced laborers aligned with advanced productive forces in the era of technological revolution and industrial transformation. This new type of labor force is not only concentrated in emerging industries and business forms such as big data, cloud computing, and intelligent manufacturing but also widely active across all sectors of the national economy. They utilize advanced production tools and are proficient in intelligent, digital, and information-based production technologies, serving as the main force driving industrial transformation and upgrading. To build a high-quality new labor force, education should serve as the foundation, science, and technology as the guidance, and talent as the support, while deepening institutional reforms in the fields of education, science and technology, and talent.

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