Research on Regional Economic Development of Guizhou Province Based on the Construction of Indicator System of New Quality Productive Forces

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Abstract. The development of new quality productive forces is essential for adapting to the evolving demands of the times and the complexities of the international landscape. It also serves as a robust foundation for promoting regional economic development. This study focuses on Guizhou Province as the research area and selects seven indicators representing three dimensions of new quality productive forces: scientific and technological innovation, green development, and high-quality development. By employing principal component analysis, a linear regression model was constructed to investigate their impact on regional development. The findings reveal that new quality productive forces exert a significantly positive influence on the economic development of Guizhou Province, particularly in the areas of scientific and technological innovation, green development, and high-quality development. For instance, the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) and the new energy industry exemplify new quality productive forces, promoting talent aggregation, scientific research, industrial upgrading, and regional coordination. Additionally, they boost the tertiary sector, thereby increasing regional GDP. Furthermore, institutional innovation is vital for advancing new quality productive forces, yet current tax and innovation policies need refinement. This study provides theoretical and practical insights for Guizhou Province and other regions aiming to leverage new quality productive forces for high-quality regional economic development.

Keywords: New Quality Productive Forces, Regional Economic Development, Green Development, Regional Policy.

1. Introduction

Globalization and technological advancements, such as AI, IoT and blockchain, have intensified the demand for new economic drivers. In response, China's new quality productive forces—centered on innovation, green development, and high efficiency—have emerged as a strategic approach to achieve high-quality development and modernization. New quality productive forces represent an advanced form of productivity that centers on scientific and technological innovation, integrating new technologies, emerging fields, and innovative models. Emphasizing innovation-driven development and high-quality growth, they are characterized by high technology, high efficiency, and high quality, signifying a transition from traditional extensive productivity to digital, green, and intelligent productivity. At their core, new quality productive forces aim to promote coordinated, sustainable, and green low-carbon development in the economy and society by integrating data as a key factor and enhancing total factor productivity. From a geographical perspective, new quality productive forces can be understood as the capacity to harmonize the evolving human-land relationship and promote the harmonious coexistence of humans and nature in the Anthropocene era, where human activities dominate. They represent a form of protective productivity that transforms "lucid waters and lush mountains" into "gold and silver mountains," an advanced productivity that drives high-quality development and spatial planning, and a beautiful productivity that comprehensively advances the construction of a Beautiful China [1]. Research on new quality productive forces holds significant practical importance for promoting high-quality regional economic development. As a representative of advanced productivity, new quality productive forces can substantially enhance a region's innovation capacity and core competitiveness, drive the optimization and upgrading of industrial

structures, and facilitate green and sustainable development. Simultaneously, they can promote coordinated development among regions, narrow regional development gaps, and advance the equalization of public services, thereby improving the overall development level and well-being of residents. By developing new quality productive forces, regions can not only achieve economic growth but also attain coordinated progress in social development, environmental sustainability, and cultural prosperity. This provides strong momentum for building a new regional development paradigm that is more advanced, efficient, equitable, and sustainable, ultimately meeting the people's growing aspirations for a better life.

Existing studies have explored new quality productive forces from various perspectives. For instance, Wen Feng'an analyzed new quality productive forces from the perspective of urban-rural integrated development [2]. Zhu Zhe and Fang Meiyu examined the positive role of new quality productive forces through the lens of deep integration between digital trade and the real economy [3]. Lin Xiaohong discussed the impact of fiscal and tax system reforms on promoting the development of new quality productive forces [4]. However, empirical research on the relationship between new quality productive forces and economic development in specific regions remains relatively limited and warrants further exploration.

This study selects Guizhou Province as the research subject and constructs an evaluation system for new quality productive forces. The standardized data method is employed to eliminate the influence of dimensional differences. On this basis, a regression model is established to examine the relationship between new quality productive forces and regional GDP. Through empirical analysis, the study investigates the impact of new quality productive forces on regional economic development, identifies existing challenges, and proposes recommendations. The findings provide a theoretical foundation for Guizhou Province and similar regions to leverage new quality productive forces in achieving high-quality economic development.

2. Theoretical analysis of regional economic development based on new quality productive forces

2.1. Selection of the area of analysis

Guizhou Province is currently focusing on the development of new quality productive forces, with a particular emphasis on advancing three key areas: intelligent computing, the cultivation of industry-specific large-scale models, and data training. The province is actively building computing power infrastructure to establish itself as a national computing power guarantee base. Simultaneously, it is seizing opportunities in the development of the low-altitude economy to create an integrated new landscape for low-altitude industries. The added value of the digital economy accounts for 42% of the province's GDP, exceeding one trillion yuan, and its comprehensive computing power level ranks among the highest in the country. These achievements provide strong momentum for the development of new quality productive forces. This paper selects Guizhou Province as the subject of analysis, as illustrated in Figure 1.

Figure 1. Administrative divisions of Guizhou Province

2.2. Selection of variables

The model consists of the following elements:

(1) Dependent Variable: Regional Gross Domestic Product (GDP), which is the total market value of all final goods and services produced by resident units within a region over one year. In this study, the standardized regional GDP (std_GDP) is selected as the proxy variable.

(2) Core Explanatory Variable: New Quality Productive Forces (NQPF). In this study, we selected seven variables to measure the intensity of newquality productive forces. These variables include: the number of students enrolled in regular higher education institutions (UniEnroll, per person), the number of scientific research institutions (InstCount, per unit), the ratio of internal funding for research and experimental development projects to regional gross domestic product (R&D/GDP, %), changes in energy consumption per ten thousand yuan of added value in large-scale industries (EnergyChange, ten thousand standard coal tons), electricity consumption per ten thousand yuan of regional GDP (ElecCons, kilowatt-hours/ten thousand yuan), coal consumption per ten thousand yuan of regional GDP (CoalCons, tons/ten thousand yuan), and the ratio of added value from tertiary industry to regional GDP (TertVA/GDP, %). Principal Component Analysis (PCA) was employed to construct the evaluation system for newquality productive forces.

(3) The data used in this study are primarily derived from officially published statistical sources. Specifically, indicators representing science and technology, energy efficiency, and the three industries for the period 2012–2021 were selected from the China Statistical Yearbook and the Guizhou Statistical Yearbook. The descriptive statistical analysis results of the variables are presented in Table 1. In the following table, Std.err means standard error.

Table 1. Descriptive statistical analysis

Variable	Observation	Mean	Std.err	Minimum	Maximum
UniEnroll	10	201159.1	57636.77	127963	277696
InstCount	10	678.8	252.3524	332	993
R&D/GDP	10	0.0062363	0.0013541	0.0047178	0.0083233
EnergyChange	10	-7.322	3.090371	-13.39	-3.4
ElecCons	10	1252.2	312.5685	903	1742
CoalCons	10	1.255	0.5894112	0.64	2.22
TertVA/GDP	10	0.4825048	0.228436	0.4438999	0.5079109

2.3. Processing of data

(1) Correlation Analysis

Before conducting principal component analysis (PCA), the data were normalized using the min-max normalization method to eliminate the influence of dimensional differences and enhance the interpretability of the model. Additionally, it is necessary to assess whether the data are suitable for PCA. Based on the correlation matrix, significant linear relationships and strong correlations are observed among the variables. The correlation matrix is presented in Table 2.

Table 2. Correlation matrix

Variable	InstCount	R&D/ GDP	UniEnroll	EnergyChange	ElecCons	CoalCons	TertVA/ GDP
InstCount	1.0000						
R&D/GDP	0.9122	1.0000					
UniEnroll	0.9808	0.9602	1.0000				
EnergyChange	-0.9563	-0.8564	-0.9409	1.0000			
ElecCons	-0.9563	-0.8564	-0.9409	1.0000	1.0000		
CoalCons	-0.9780	-0.8937	-0.9722	0.9821	0.9821	1.0000	
TertVA/GDP	0.7894	0.9091	0.8383	-0.6979	-0.6979	-0.7469	1.0000

(2) Determining the Number of Principal Components

Principal component analysis (PCA) was conducted, and the number of principal components was determined based on the criterion of eigenvalues greater than 1, as shown in Table 3. The selected principal components have a contribution rate of 0.9143, with a cumulative contribution rate of 0.9143.

Table 3. Correlation matrix

Component	Eigenvalue	Difference	Proportion	Cumulative
1	6.39998	5.92295	0.9143	0.9143
2	0.47703	0.41490	0.0681	0.9842
3	0.06213	0.02064	0.0089	0.9913
4	0.04194	0.02801	0.0060	0.9973
5	0.01348	0.00804	0.0019	0.9992
6	0.00544	0.00544	0.0008	1.0000
7	0.00000	.	0.0000	1.0000

(3) Calculation of Comprehensive Scores and Regression Analysis

Based on the results above, the principal component scores were linearly weighted using the proportion of variance contribution to the total variance contribution as the weight, and the comprehensive score was calculated. The component with the highest score, Comp1, was selected for regression analysis. At the 1% significance level, the overall significance test was passed, and the regression analysis results are presented in Table 4.

Table 4. Regression analysis results

Variable	Ratio	Std.err	t value	P value
Comp1	0.132755	0.0100073	13.27	0.000
Intercept term	0.4840146	0.0240174	20.15	0.000

2.4. Model building

The regression equation derived from the data in Table 3 is presented below, where β0 and β1 denote the coefficients:

$$std\_GDP = \beta_1 NQPF + \beta_0 \quad (1)$$

The model indicates the impact of new quality productive forces (NQPF) on the standardized regional gross domestic product (GDP). Component 1 (Comp1) was selected as the proxy variable for NQPF, as follows:

$$std\_GDP = 0.132755Comp1 + 0.4840146 \quad (2)$$

Each principal component is a linear combination of the original variables, and the loadings represent the weights of the original variables on the principal components. These loadings indicate the contribution of each original variable to the principal components. The loadings obtained from the principal component analysis were used to construct the principal components, where positive loadings indicate a positive correlation and negative loadings indicate a negative correlation. The loadings for Component 1 (Comp1) are presented in Table 5.

Table 5. Principal component loadings

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
std_InstCount	0.3890	-0.1058	0.1942	0.6876	0.5084	-0.2617
std_(R&D/GDP)	0.3768	0.3532	0.5302	-0.5625	0.1771	-0.3230
std_EnergyChange	-0.3813	0.3508	0.3330	0.2762	-0.1863	-0.0978
std_ElecCons	-0.3813	0.3508	0.3330	0.2762	-0.1863	-0.0978
std_CoalCons	-0.3883	0.2307	-0.0152	-0.1398	0.7649	0.4372
std_(TertVA/GDP)	0.3335	0.7505	-0.5489	0.1394	-0.0611	0.0325
std_UniEnroll	0.3922	0.0380	0.3972	0.1387	-0.2276	0.7848

The expression for Component 1 (Comp1) is derived as follows:

$$Comp1 = 0.3922y_1 + 0.3890y_2 + 0.3768y_3 - 0.3813y_4 - 0.3813y_5 - 0.3883y_6 + 0.3335y_7 \quad (3)$$

Here, y1 represents std_UniEnroll, y2 represents std_InstCount, y3 represents std_(R&D/GDP), y4 represents std_EnergyChange, y5 represents std_ElecCons, y6 represents std_CoalCons, and y7 represents std_(TertVA/GDP).

2.5. Analysis of results

The indicators std_UniEnroll, std_InstCount, and std_(R&D/GDP) represent the level of technological innovation. The indicators std_EnergyChange, std_ElecCons, and std_CoalCons reflect the level of green development (energy utilization metrics, where lower values indicate higher energy efficiency). The indicator std_(TertVA/GDP) represents the level of high-quality development. Component 1 (Comp1) exhibits a positive correlation with std_UniEnroll, std_InstCount, and std_(R&D/GDP), a negative correlation with std_EnergyChange, std_ElecCons, and std_CoalCons, and a positive correlation with std_(TertVA/GDP). These findings align with economic theory, indicating that the development of new quality productive forces can significantly influence regional economic development. This is particularly evident in the areas of scientific and technological innovation, green development, and high-quality development.

3. Empirical analysis of new quality productive forces on regional economic development

3.1. Leveraging New Quality Productive Forces for Scientific and Technological Innovation: A Context-Specific Approach

Narrowing regional development disparities is conducive to the long-term development of regions. Excessive disparities between regions can undermine political stability and require significant resource allocation to support less-developed areas, which may lead to inefficient resource distribution. To address this, emerging industries can be developed in specific regions based on local

conditions, leveraging the innovative advantages of new quality productive forces to attract new talent. A notable example is the Five-hundred-meter Aperture Spherical Radio Telescope (FAST).

FAST, located in Guizhou's karst region, exemplifies the synergy between natural advantages and technological innovation. Its construction reduced costs through the natural landscape, while its operation has attracted research talent and advanced local scientific capabilities.

FAST has significantly boosted local economic development. The scientific and technological innovation advantages of new quality productive forces have played a pivotal role in this process. First, FAST itself serves as a tangible embodiment of new quality productive forces, demonstrating their strong driving force in the field of scientific and technological innovation. The project's adoption of advanced technologies, such as the lightweight cable-driven control system and other technical innovations, has not only earned national awards but also significantly improved observation efficiency and research output through intelligent operation and management. Furthermore, leveraging its powerful computing capabilities, FAST has enabled efficient processing of massive datasets and sustained progress in scientific research and innovation. The deployment of these cutting-edge achievements in Guizhou has attracted a large number of high-caliber domestic and international talents, leading to an increase in the number of local research institutions and greater investment in research and development. Finally, the successful translation and implementation of these research outcomes have driven local economic growth. This aligns with the model's expectation that increases in indicators such as the number of research institutions and the ratio of internal R&D expenditure to regional GDP would positively contribute to regional GDP growth.

3.2. Green development contributes to high-quality development of regional economy

Energy transformation is a strategic precursor to the advancement of productive forces, and new energy is a critical component of new quality productive forces. Against the backdrop of a new round of technological revolution and the transition to a low-carbon economy, China's new energy industry has become a vital foundation for securing international technological leadership and promoting green, low-carbon development [5]. In the model, EnergyChange, ElecCons, and CoalCons represent energy efficiency indicators, specifically the energy consumption per RMB 10,000 of industrial added value, electricity consumption per RMB 10,000 of regional GDP, and coal consumption per RMB 10,000 of regional GDP, respectively. Lower values of these indicators signify higher energy efficiency, which in turn implies lower production costs per unit of output and reduced costs for addressing environmental issues caused by production. This effectively enhances regional competitiveness and drives regional economic development. Promoting the development of new quality productive forces can significantly reduce these indicators.

New quality productive forces empower green development through 'new energy' [6]. The role of the new energy industry in promoting regional economic development is first reflected in its ability to drive industrial upgrading and spatial agglomeration. The development of new energy relies on the support of emerging industries, which can spur the growth of new industries and facilitate the transformation and upgrading of traditional enterprises into the new energy sector. At the same time, due to considerations such as technological exchange and cost efficiency, these new energy industries often exhibit agglomeration effects, thereby achieving economies of scale and providing comprehensive industrial chain support for the development of the entire new energy sector. This injects new vitality into the economic growth of agglomerated regions. For example, Guizhou Province has attracted investments from companies such as CATL, BYD, and Zhongwei Co., Ltd., making the new energy battery and materials industry a new growth pole supporting the rapid development of the province's industrial economy.

Secondly, the new energy industry plays an important role in optimizing regional industrial structure. Traditionally, some regions have relatively single industrial structures and insufficient development momentum due to historical reasons such as resource endowment. However, the rise of the new energy industry provides these regions with opportunities for transformation and upgrading. By introducing new energy projects and cultivating new economic growth points, it can drive the

development of related industrial chains and promote the optimization and upgrading of regional industrial structure.

Lastly, the new energy industry also plays a significant role in promoting coordinated regional economic development. The layout of new energy industry land can guide the flow of capital, technology, and talent to underdeveloped areas, narrowing the development gap between regions. At the same time, the construction of new energy projects can drive local infrastructure construction, increase employment, and enhance income, promoting the balanced development of the regional economy.

3.3. High-quality development of new quality productive forces

3.3.1. New quality productive forces and the tertiary sector

New quality productive forces are characterized by high quality, effectively enhancing total factor productivity, promoting the efficient allocation and utilization of resources, and thereby achieving high-quality economic development. They focus on capturing the high ground of strategic emerging industries and future industries through disruptive technological innovations, thereby strengthening independent innovation capabilities. The tertiary industry, particularly modern services, is the primary application domain of new quality productive forces, and its development level serves as a key indicator for measuring the progress of new quality productive forces. The development of new quality productive forces not only pursues improvements in production efficiency and quality but also emphasizes the innovation and enhancement of productivity in areas such as new technologies, new materials, and new energy. In particular, the growth of value-added in high-tech and knowledge-intensive industries within the services sector has become a new driving force for high-quality development.

According to the Petty-Clark Theorem: As the economy develops and per capita national income rises, rural areas will gradually experience a surplus of labor. This labor force migrates from rural to urban areas, leading to a gradual decline in the relative share of national income and labor in the primary sector and an increase in the share of national income and labor in the secondary sector. With further economic development, when the labor force in the secondary sector becomes saturated, the surplus labor shifts to the tertiary sector, resulting in an increase in the share of national income and labor in the tertiary sector.

According to the model, TertVA/GDP represents the ratio of the tertiary industry's value-added to regional GDP, serving as an important indicator for evaluating economic development. With the continuous development of new quality productive forces, the ratio of the tertiary industry's value-added to regional GDP will steadily increase, thereby driving the growth of regional GDP.

3.3.2. Tertiary sector and regional economic development

The tertiary industry plays a pivotal role in the national economy, and its development quality directly affects the speed and quality of economic growth [7]. Modern services are crucial for ensuring the steady development of the national economy and are essential components of the transformation from high-speed economic growth to high-quality development. Vigorously developing modern services can accelerate industrial structure optimization, improve labor employment rates, and promote coordinated economic and social development [8]. Newquality productive forces, as an advanced form of productivity driving high-quality development, will boost the development of modern services, particularly in scientific research and technology services.

For instance, Guizhou has established the Guizhou Radio Astronomy Observatory by leveraging FAST to create a top-tier astronomical research and science popularization base. Meanwhile, it is accelerating the integrated development of Guizhou Science City, Guiyang Big Data Sci-Tech Innovation City, Huaxi University Town, and Qingzhen Vocational Education City, as well as constructing the Zunyi Science and Technology Innovation Center, among others [9]. This initiative has facilitated the growth of local scientific research services. Additionally, Guizhou Province has developed an astronomy research, science tourism, and youth science education base around FAST,

investing approximately 5 billion yuan in the creation of 13 complementary tourism projects. This investment has enhanced the value of the region's tourism service industry, thereby boosting the economic development of Pingtang County and its surrounding areas. Data shows that Guizhou's regional GDP has grown, with the speed of digital economy growth ranking at the forefront nationwide, indicating the optimization of economic structure and the transformation of growth momentum. This suggests that new quality productive forces play an active role in promoting high-quality regional economic development, aligning with the expectations of the model.

4. The need for institutional innovation on new quality productive forces

4.1. Institutional Innovation: Adapting Production Relations to New Quality Productive Forces

New quality productive forces represent a leap in productivity driven by the rapid development of new rounds of technological revolutions and industrial transformations. Based on the need to adapt to disruptive technological innovations, continuous institutional innovations in related fields are essential, leading to the formation of new production relations, which is an inherent requirement for accelerating the development of new quality productive forces [10]. Productivity and production relations are characterized by a dialectical unity; the level and nature of productivity directly shape the specific forms of production relations. As productivity advances, when it reaches a critical stage, if existing production relations fail to match this development, they become obstacles to progress, triggering profound social changes and giving rise to new production relations. Conversely, production relations also exert significant counter-effects on productivity. Those relations that align with productivity development can further promote its growth, while those that do not can hinder it.

Therefore, appropriate regional policies must be coordinated with new quality productive forces to ensure its stable implementation. For instance, when deploying new quality productive forces in some peripheral cities, relying solely on market mechanisms to allocate resources without corresponding institutional support may result in unbalanced development, as capital tends to concentrate in major cities. In such cases, government-led institutional innovations are necessary to develop regional policies that are compatible with new quality productive forces, ensuring its stable deployment.

4.2. Policy Recommendations: Tax and Innovation Coordination

New quality productive forces require substantial financial support and long-term policy stability. However, current tax policies predominantly target specific industries such as biopharmaceuticals, energy conservation, and new energy. Nevertheless, many emerging industries or products, such as advanced manufacturing and digital creative products and services, have not received corresponding tax policy support [11]. Local governments should expand tax preferential coverage to include these industries and enhance support for R&D investment.

Innovation policies, by integrating science and technology resources and guiding the innovative allocation of production factors, accelerate the formation of new quality productive forces, serving as a policy tool for achieving high-quality economic development [12]. For example, Guizhou Province has prioritized scientific innovation through its six major industrial bases and implemented strategic actions to integrate technology with industrial upgrades. Additionally, talent incentives such as the Action Plan for Promoting High-Quality Development through Science and Technology Introduction to Guizhou highlight the importance of attracting high-end talents and optimizing services for innovation entrepreneurship. These coordinated efforts demonstrate how tax and innovation policies can jointly drive the development of new quality productive forces.

5. Conclusions

This study demonstrates that new quality productive forces—through technological innovation exemplified by FAST, green development driven by energy efficiency, and tertiary sector growth—are a crucial safeguard for the high-quality development of regional economies in China, as evidenced by Guizhou's practices. Governments should strategically integrate such forces into national development strategies while avoiding premature deployment in unsuitable contexts to prevent resource misallocation. As their impact intensifies, policymakers must refine supporting policies to address emerging challenges. Future research could extend this framework to other regions, explore synergies between new quality productive forces and global sustainability agendas, and assess how advanced technologies like AI and big data can further optimize productivity measurement and policy design.

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