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The influence of new quality productivity on regional high-quality development under artificial intelligence

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Abstract: *With the rapid advancement of artificial intelligence technology, new quality productivity has gradually become a key driver of high-quality regional economic development. To explore the role of AI in promoting the five major development concepts in regional economies, this paper employs the entropy weight method and multiple linear regression models to analyze the formation mechanism of new quality productivity and its impact on regional high-quality development. Additionally, a spatial econometric model is applied for empirical testing, further confirming the robustness of the study's conclusions. The regression coefficients of AIU, IDR, and BDI indicate an improvement in accuracy compared to previous research. The data used in this study is sourced from the China Statistical Yearbook, enhancing the reliability and reference value of the model results.*

Keywords: *Artificial Intelligence, New Quality Productivity, Spatial Durbin Model, Regional Economic Development, Evaluation Index System*

1. Introduction

With the rapid development of artificial intelligence (AI) technology, we are entering an era characterized by intelligence and data-driven processes. In this context, new-quality productivity, as a qualitative leap in traditional productivity, is gradually becoming a central driving force behind regional high-quality development. It not only represents an upgrade in productivity but also demonstrates unprecedented growth potential, fueled by AI technologies. From the perspective of AI, studying the impact of new-quality productivity on regional high-quality development holds significant theoretical and practical value. It not only deepens our understanding of the concept and characteristics of new-quality productivity but also provides new strategies and insights for advancing regional economic development towards high-quality outcomes.

Previously, Jianhua Xiao and Duanmei Hu developed an evaluation system for the high-quality development of Guangdong's marine economy, based on five new development concepts. They used the entropy method to quantitatively assess the development status from 2015 to 2017 [1]. Xuesong Gao and Xuefang Liu employed the Spatial Durbin Model (SDM) and various statistical methods to explore the effects of AI on new-quality productivity and its spatial spillover effects [2]. Moreover, Xiangyu Hua, Haiping, and Xiangrong Ji used the SBM-DDF model, spatial autocorrelation model, and Tobit model to effectively evaluate the efficiency of high-quality development and total factor productivity (TFP) in China's regional economy [3]. Lingui Li and Li Liu introduced the concept of new-quality productivity, offering a fresh perspective for understanding and promoting high-quality productivity in line with new development concepts [4].

In addition, considering the spatial interconnections between regional economic developments, this paper employs spatial econometric models, particularly the Spatial Durbin Model (SDM). Based on the new development concepts proposed by China in 2015, five secondary indicators—innovation, coordination, green development, openness, and sharing—are identified as key drivers of high-quality development. Using data from 2016 to 2023, four tertiary indicators under each secondary indicator are selected for more practical analysis. These indicators are then used to construct a regional high-quality development evaluation system, ensuring greater accuracy and representativeness.

1) This paper uses the entropy weight method to determine indicator weights, providing an objective and accurate assessment of regional high-quality development, enhancing both efficiency and credibility.

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2) It constructs a multiple linear regression model to flexibly explore the relationships between various indicators and regional economic development, offering both explanatory power and predictive capabilities.

3) The paper applies the Spatial Durbin Model to comprehensively analyze interregional influences, deepening the understanding of the spatial effects of new-quality productivity on development.

2. Related Work

2.1 Evaluation Indicator System for High-Quality Economic Development

Studies such as those by Zhou, J., Hu, et al., and Wang, Xiaojie, et al., have constructed evaluation systems for high-quality economic development, but they lack in-depth analysis of the indicator system's universality, timeliness, adaptability, flexibility, and policy guidance effectiveness [5-8]. Our model, incorporating current policies and real data from the National Bureau of Statistics, establishes four tertiary indicators under each development concept, constructing a more scientific comprehensive evaluation system.

2.2 Spatial Durbin Model

Research by Haoran Wang, et al., Jing Deng, et al., Qing sheng Zhu, et al., and Cui, Z., et al., have applied the Spatial Durbin Model but face issues like the rationality of spatial weight matrix selection, model parameter estimation accuracy, and model explanatory power limitations [9-13]. We introduce the entropy weight method and multiple linear regression model to overcome data limitations, providing a more concise and effective analysis framework.

2.3 New-Quality Productivity

Studies by Zhang, Haohan, et al., Gu, Tianyu, et al., Zhang, J., Shan, et al., and Wu, Jin, et al., focus on the impact of new-quality productivity in specific fields like regional economy and agriculture, lacking comprehensive exploration of its applications in other areas [14-17]. Our study considers the comprehensiveness and accuracy of new-quality productivity across the five development domains, providing a scientific basis for policy formulation.

3. Model

Data from different social regions in Shaanxi Province from 2016-2023, combined with micro-data from related enterprises and industries, are analyzed using the entropy weight method, linear regression, and spatial econometric models to reveal how the popularization and application of AI technology accelerate the formation of new-quality productivity. The whole process is shown in figure 1.

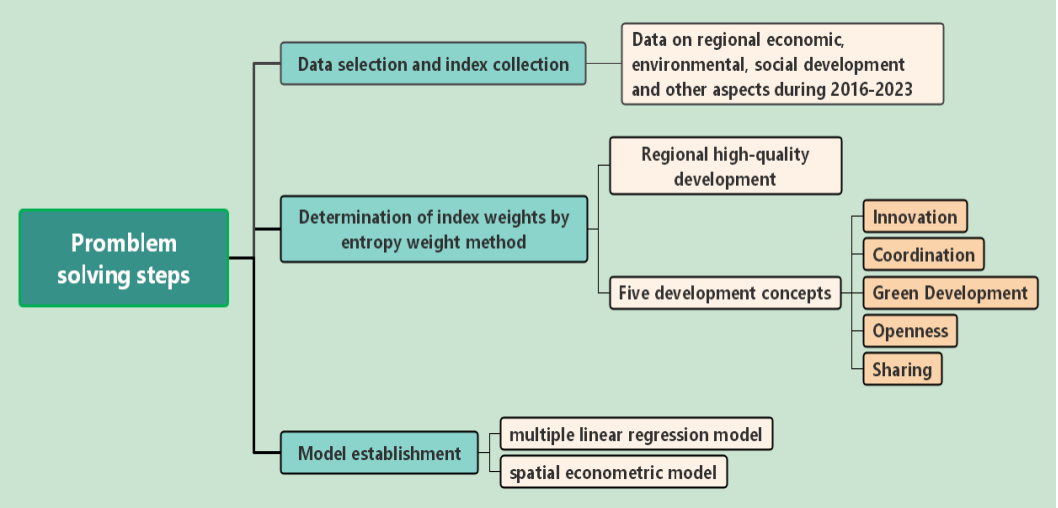

Figure 1. Flow Diagram

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3.1 Entropy Weight Method

Inspired by Jianhua Xiao and Duanmei Hu, the entropy weight method is used to determine the weights of 20 tertiary indicators under of the 5 secondary indicators (4 for each). The 5 tertiary indicators with the highest weights are selected for further analysis.

(1) Data Standardization

Normalize the data for each indicator. Suppose k indicators are given: $X_1, X_2, \ldots, X_n$, and $X_i = \{X_1, X_2, \ldots, X_n\}$. Assume if the normalized value of the data for each indicator is $Y_1, Y_2, \ldots, Y_n$, then:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{1}$$

(2) Information Entropy Calculation

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{2}$$

Where,

$$P_{ij} = Y_{ij} / \sum_{i=1}^{n} Y \tag{3}$$

If $P_{ij} = 0$, then:

$$\lim_{p_{ij} \to 0} p_{ij} \ln p_{ij} = 0 \tag{4}$$

(3) Weight Determination

Determine the weight of each indicator, which are $E_1, E_2, \ldots E_n$ based on its information entropy W_i .

$$W_i = \frac{1 - E_i}{k - \sum E_i} (i = 1,2,\ldots,k) \tag{5}$$

The entropy weight method determines objective weights based on indicator variability. Lower information entropy indicates greater variation and more information, leading to higher weights in comprehensive evaluation. This method identifies critical indicators affecting five development concepts, guiding precise development directions for new AI productive forces.

3.2 Multiple Linear Regression Model

A multiple linear regression model is constructed to explore the specific impact mechanisms of the five key indicators identified by the entropy weight method on regional high-quality development.

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_k X_{ki} + \mu_i \ (i = 1,2, \cdots n) \tag{6}$$

The multiple linear regression model, for $K - 1$ explanatory variables, Y uses for the dependent variable, $X_1, X_2 \ldots, X_n$ for independent variables, $\beta_1, \beta_2, \beta_3, \ldots, \beta_n$ for parameters, and μ_1 for error. It handles complex relationships, quantifies influences on regional high-quality development, aids understanding of core indicators' synergy, and supports precise strategies via its wide applicability and reliable inference, advancing high-quality development goals.

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3.3 Spatial Durbin Model

The Spatial Durbin Model reveals significant positive correlations in high-quality development across different regions, indicating that the status of high-quality development among regions is not independent but mutually influential. This may be due to the high similarity in economic development patterns, industrial structures, policy environments, and other aspects, leading to a spatial aggregation effect of high-quality development. It is implied that spatial effects need to be considered.

The Spatial Durbin Model (7) is constructed to further test the impact of new-quality productivity on regional high-quality development.

$$\ln TCI_{it} = \rho W \ln TCI_{it} + \beta_1 \ln TFP_{it} + \varphi_1 W \ln TFP_{it} + \beta_2 \ln X_{it} + \varphi_2 \ln X_{it} + u_i + \sigma_t + \varepsilon_{it} \quad (7)$$

In Equation (7), i and t represent the district/county and year respectively, ρ is the spatial lag coefficient; W is the spatial weight matrix, and in this study, the reciprocal of distance is used as the spatial weight. TCI_{it}represents the level of new-quality productivity in district/county i in year t, TFP_{it} represents the high-quality development score, and X_{it} represent the control variables selected for the study. u_i denotes the regional fixed effect, σ_t denotes the year fixed effect, ε_{it} and represents the random disturbance term.

This model not only inherits the advantages of traditional econometric models but also effectively captures the spatial dependence and spatial heterogeneity among variables, thereby more accurately revealing the spatial spillover effect of new-quality productivity on high-quality development. Through the testing of the Spatial Durbin Model, we can deeply analyze how the diffusion and spillover of artificial intelligence technology affect the high-quality development of neighboring regions, providing a powerful basis for decision-making in formulating scientific regional development policies and promoting coordinated regional development.

4. Experiment

4.1 Data Collection

The concept of "Artificial Intelligence" was first proposed in March 2016. Thus, data from 2016-2023 is used to measure indicators accurately. Other control variables are introduced due to various influencing factors.

4.2 Analytical Indicators

This paper explores the impact of new-quality productivity on regional high-quality development from an AI perspective and its spatial differences. Considering China's new economic normal and global recovery needs, the new development paradigm aligns with national conditions. 5 secondary indicators are under each for practical analysis as the following table 1.

Table 1. Selection and Description of Data set Variables

Level 1 indicators	Level 2 indicators	Level 3 indicators	Indicator instructions
High-quality economic development	Innovative development	The GDP growth rate (+)	Regional GDP growth rate
		R & D funding (+)	R & D funding input
		Fixed-asset investment grew (+)	Growth rate in fixed-asset investment
		The GDP growth rate of industries above designated size (+)	The GDP growth rate of industrial enterprises above designated size
	Harmonious development	Total retail sales of social consumer goods (+)	Total retail sales of social consumer goods
		Township structure (+)	Urbanization rate
		Contribution rate of GDP growth: the tertiary industry (+)	The tertiary industry to the regional GDP ratio increased
		Local financial expenditure: general budget expenditure (+)	Local financial expenditure: general budget expenditure
	Green development	Energy consumption per unit of GDP (-)	Standard coal / zone CDP
		The elasticity coefficient of energy consumption (-)	Growth rate of energy consumption / GDP growth rate

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		Wastewater per unit of output (-)	Total wastewater discharge / regional DP
		The exhaust gas per unit of output (-)	Sulfur dioxide emissions / regional GDP
	Open development	Foreign trade dependence (+)	Total import and export volume / region C
		The proportion of foreign investment (+)	Actual utilization of foreign investment / region
		Degree of marketization of the market (+)	Regional market-oriented index
		Financial development level (+)	Various loan growth amount / regional CDP
	Shared development	The proportion of labor remuneration (+)	Average worker wage / regional CIP
		Resident income growth elasticity (+)	Per capita disposable income growth rate / regional growth rate
		Rural consumption gap (-)	Qi town residents per capita consumption expenditure / rural residents per capita consumption expenditure
		The proportion of peoples livelihood government expenditure (+)	The proportion of the general public service expenditure in the local fiscal budget expenditure

Table 2. Innovation Indicator Weights by Entropy Method

Item	Information entropy value e	Information utility value d	weight (%)
GDP rate of rise	0.907	0.093	23.436
Growth rate in fixed-asset investment	0.877	0.123	31.026
R&D investment (100 million yuan)	0.897	0.103	25.968
The GDP growth rate of industrial enterprises above designated size (%)	0.922	0.078	19.57

As can be seen from the above table 2, the weight of GDP growth rate is 23.436%, the weight of fixed asset investment growth rate is 31.026%, the weight of R&D expenditure (in billions of yuan) is 25.968%, and the weight of GDP growth rate of industrial enterprises above a certain size is 19.57%. Among them, the maximum weight is assigned to the fixed asset investment growth rate (31.026%). Therefore, the fixed asset investment growth rate is selected as the indicator representing the weight of innovative development.

4.3 Comparative Experiment

Compared to existing papers that examine the impact of new-quality productivity on regional high-quality development from an artificial intelligence perspective, this paper establishes a relatively comprehensive comprehensive indicator system for economic high-quality development. Furthermore, the data sets are sourced from official channels, making them more comprehensive and accurate. Additionally, this paper considers the connections among various variables, using specific empirical analysis and model building to further verify and support the research viewpoints.

4.4 Conclusions

New-quality productivity drives regional high-quality development, with AI technology significantly boosting production efficiency. Key indicators within the five major concepts (innovation, coordination, green development, openness, sharing) have varying impacts on regional development. Specifically, fixed asset investment growth and urbanization rate positively affect innovation and coordination, while wastewater per unit of output hinders green development. Adjacent regions exhibit negative correlation in economic development, indicating competitive relationships in high-quality development. The spatial econometric model shows that past high-quality development positively influences present development, suggesting the importance of historical foundation and potential in formulating regional strategies.

4.5 Policy Suggestions

To lead innovative development, integrate AI technology throughout the process. AI R&D investment on AI need to be increased. The government should establish funds to support enterprises and research institutions in AI R&D, fostering technological innovation.

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5. Conclusion

This paper employs the Spatial Durbin Model, entropy weight method, and linear regression to study new-quality productivity and regional high-quality development. The entropy weight method provides scientific weights. The paper innovatively builds a high-quality development indicator system based on innovation, coordination, green development, openness, and sharing, reflecting China's social development. Spatial econometric models show spatial differences and negative correlations in adjacent regions' high-quality development, aiding policymakers.

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