

# Dynamic Simulation Analysis Based on the Evaluation of Transformation Performance of Puyang City

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**Abstract.** This paper takes Puyang City, Henan Province as an example to study its current transformation effect. It sets up five dimensions of economic benefit, resource benefit, people's livelihood development, ecological efficiency and scientific and technological construction level, and analyzes the impact of Puyang City through the entropy weight-TOPSIS model. Key indicators of transformation, and use the super-efficiency DEA model to measure the efficiency value of five dimensions year by year. After the evaluation of the transformation performance measurement system, it is found that the current urban transformation of Puyang is progressing well; from the research results, the transformation effect of Puyang city mainly depends on the high-quality development of resource efficiency and scientific construction, which will continue to promote more efficient and sustainable development in the future. Sustained development provides ideas, and also serves as a reference for other resource-based cities like Puyang to implement transformation.

**Keywords:** entropy weight-TOPSIS model ; super-efficiency DEA model ; sustainable development.

## 1. Introduction

In recent years, sustainable development, as a long-term goal pursued by human beings, has received extensive attention from all over the world. In 2013, the "Sustainable Development Plan for Resource-Based Cities in my country (2013-2020)" (hereinafter referred to as the "Plan") issued by the General Office of the State Council clearly defined national resource-based cities, specifically referring to mineral deposits, forests, etc. in the region. A city where resource development, processing and utilization are the leading industries. The "Planning" shows that since the founding of the People's Republic of China, resource-based cities have produced a total of 58.4 billion tons of raw coal and crude oil (including 5.5 billion tons of crude oil), 5.9 billion tons of iron ore, and 2 billion cubic meters of wood. The economic development of China has provided a strong impetus and important guarantee. However, due to the continuous exploitation and consumption of natural resources, the accumulated reserves of many resource-based cities in China have exceeded 70% of their recoverable reserves, and these cities are facing the risk of resource depletion . To achieve long-term sustainable development, cities must take the road of transformation.

## 2. Research Methods and Data

### 2.1 Research data

The social and economic data are directly or indirectly calculated from Puyang City's 2010-2020 Statistical Yearbook, 2009-2019 Environmental Development Bulletin, 2009-2019 National Economic and Social Development Statistical Bulletin and other related papers. We eliminate the indicators with too many missing values to construct an evaluation index system according to the independent variables that meet the requirements. Finally, the evaluation index system of resource-based city transformation performance can be divided into: economic level, resource dependence, social welfare, ecological efficiency and scientific and technological construction. five dimensions.

## 2.2 Indicator Construction

The purpose of resource-based city transformation performance evaluation is to evaluate the current sustainable development of the target city, to study whether its development is reasonable, and to screen out the hindering factors according to the impact of various indicators on the city's development, so as to provide a follow-up study on how the city can achieve a higher level of development. Provide support for constructive suggestions for horizontal sustainable development.

In order to ensure the effect of the evaluation index system, we strictly follow the principles of scientificity and representativeness when selecting indicators at all levels, that is, the values of various indicators are officially released, and the data are authentic and accurate; at the same time, the selected indicators It reflects the level of various phenomena related to the sustainable development of the city in a refined and comprehensive manner, which not only avoids the one-sidedness caused by too few indicators, but also solves the potential difficulty of data redundancy caused by too many indicators. The details of the evaluation index system are shown in Table 1.

## 2.3 Research methods

This paper first uses the TOPSIS entropy weight method to analyze the various sub-indicators established in the five dimensions of economic efficiency, resource efficiency, people's livelihood development, ecological efficiency and scientific and technological construction level, and then uses the super-efficiency DEA model to obtain the ranking and correlation coefficient of each index. Measure the efficiency values of the five dimensions year by year. Based on the results of the evaluation system, combined with the theory of the system dynamics model, a scoring system for the transformation performance of Puyang City is established. Through the dynamic simulation analysis of the system, the key factors in the system of Puyang City are improved, and the effect analysis and urban transformation evaluation are carried out.

## 2.4 Measurement and evaluation system of urban transformation performance

In order to analyze the transformation and development of cities in a more comprehensive and multi-dimensional way, we combined the published literature and data, and firstly established 20 indicators from the five dimensions of "economic benefits, resource benefits, social welfare, ecological efficiency, and scientific and technological construction level". (see Table 1) performance evaluation system. Secondly, the entropy index method is used to obtain the corresponding index weight.

Table 1. Urban Transformation Evaluation Index System

target layer	Indicator level	Weights/%
economic benefits	GDP per capita	1.59
	GDP growth	1.45
	Primary industry as a share of GDP	18.30
	The added value of the tertiary industry	7.92
	Proportion of employment in mining industry	10.09
resource efficiency	Crude oil production	14.57
	value added of oil extraction	7.41
	Added value of petroleum processing industry	4.90
People's livelihood development	per capita disposable income of urban residents	1.74
	Per capita disposable income of rural residents	2.74
	Urban registered unemployment rate	9.3
Eco-efficiency	The rate of days with good air quality	2.33
	Number of A-level scenic spots	0.93
	Plantation area	7.42
	Comprehensive utilization rate of industrial solid waste	0.02

	The proportion of environmental protection investment in fiscal expenditure	2.65
Science and technology construction level	The number of granted patent applications	3.05
	Number of college students per 10,000 people	1.01
	Number of scientific and technological personnel per 10,000 people	1.18
	Science and technology spending as a share of GDP	1.4

The dimension of economic benefits is described from two aspects of economic growth and industrial structure, and five indicators are selected to comprehensively reflect the current economic development of resource-based cities; Resource efficiency quantifies the degree of dependence of resource-based cities on their own resources through indicators such as crude oil production, the added value of oil extraction, and the added value of petroleum processing industries. It is closely related to the quality of life and the happiness of life of residents. It mainly includes indicators such as the per capita disposable income of urban residents, the per capita disposable income of rural residents, and the registered urban unemployment rate; the ecological efficiency dimension adopts the rate of days with good air quality, the number of A-level scenic spots, the area of artificial afforestation, the comprehensive utilization rate of industrial solid waste and environmental protection. Measures such as the proportion of investment in fiscal expenditure to comprehensively reflect the level of protection of the natural environment in resource-based cities in the process of transformation;

In the dimension of science and technology construction, the number of patent applications authorized, the number of college students per 10,000 people, the number of scientific and technological personnel per 10,000 people, and the proportion of science and technology expenditure in GDP are selected to comprehensively reflect the current investment in science and technology in resource-based cities and the corresponding output effect. , is an important dimension to judge its future transformation momentum.

## 2.5 Evaluation of Urban Transformation Efficiency

The evaluation methods of urban efficiency evaluation system mainly include emergy method, index system method, data envelopment analysis method and frontier production function method with parameters. Among them, the data envelopment analysis method is the result of the fusion of multiple theoretical disciplines. The method starts from the urban input and output indicators, and uses the method of linear regression analysis to evaluate the relative effectiveness of comparable index units of the same type, and then establish a model .

It can be found that the transformation of Puyang City is better, and the overall efficiency is increasing year by year. Under the pressure of decreasing and depleting oil resources, the economic benefits of resource-exhausted cities have still increased; since Puyang City was included in the "Central Plains Economic Zone Construction Plan" in 2012, the poverty alleviation and relocation projects in the Yellow River floodplain have been included In the key poverty alleviation project of "Three Mountains and One Beach" in the province, people's livelihood has been more guaranteed. PetroChina has further expanded the scope of industrial poverty alleviation, the people's livelihood problems in Puyang have been solved, and the living standards of residents have been improved; Puyang City attaches great importance to scientific research development and talent introduction, Vigorously support the development of core technologies, continuously innovate in the manufacturing industry, and have the courage to innovate. On the other hand, since Puyang was established as a national resource-exhausted transformation pilot city, it has received key support from the state. In recent years, it has received a total of 850 million yuan of state-supported transformation and development funds. The industrial structure has been continuously upgraded, and urban development has gradually reduced the consumption of exhausted resources. The degree of dependence is reduced, and the transformation of the oil extraction industry into a mid-to-high-end

manufacturing industry such as the processing industry is accelerated. Compared with other dimensions, Puyang City still has some problems in terms of urban ecological efficiency, and there is more room for improvement. It is urgent for the government to play its leading role and strengthen guidance in green industries and green areas.

In order to analyze the transformation of urban industrial structure in Puyang City, explore the dependence of economic growth on petroleum resources. We adopt the idea of decoupling theory to further analyze the causal link between economic growth and depleting resource consumption. There are generally two evaluation indicators of decoupling theory, decoupling factor and elastic coefficient. The analysis of the decoupling factor is from the whole state from the beginning to the end, and the elastic coefficient is used to divide the decoupling and negative decoupling states at a certain point in time. The calculation method is as follows:

①Decoupling Factor (DF)

$$DF = 1 - \frac{(RC/EO)_T}{(RC/EO)_{T_0}} \quad (1)$$

②Coefficient of elasticity

$$E_t = \frac{\% \Delta RC_t}{\% \Delta EO_t} \quad (2)$$

In the formula: RC is the resource consumption, that is, the crude oil output (ten thousand tons); EO is the economic output, that is, the GDP (100 million yuan), T is the year at the end of the period, and T0 is the year at the beginning of the period.  $\% \Delta RC_t$ ,  $\% \Delta EO_t$  are the rate of change of resource consumption and the rate of change of economic output in year t, that is, the rate of change of crude oil production (%) and the rate of change of GDP (%) in year t.

Table 2. Analysis of decoupling in Puyang City from 2002 to 2019

Puyang City	2002	2003	2019
Elasticity coefficient E	0.44	1.04	-0.19
decoupling factor DF	0.14	0.27	-0.17
Decoupled state	weak decoupling	Expansion Decoupling	Strong decoupling

From Table 2, compared with 2019, the economic growth of Puyang City was significantly less dependent on oil production, from weak decoupling ( $\% \Delta RC > 0$ ,  $\% \Delta EO > 0$ ,  $E < 1$ ) or expansionary negative decoupling ( $\% \Delta RC > 0$ ,  $\% \Delta EO > 0$ ,  $E \geq 1$ ) to strong decoupling ( $\% \Delta RC \leq 0$ ,  $\% \Delta EO > 0$ ,  $E \leq 0$ ) the performance of both the decoupling process and the result is good. The degree of transformation is relatively high, the dependence on the exploitation of exhausted resources is significantly reduced, and the conversion efficiency of the driving force of economic growth is high.

### 3. Research Conclusions and Recommendations

On the whole, the transformation effect of Puyang City is good at present, which greatly enhances the confidence of other resource-based cities to achieve sustainable development. According to the analysis of different dimensions, the economic benefit dimension of Puyang City has little volatility, and showed a downward trend after reaching the peak in 2017; at the same time, the ecological efficiency continued to rise for three consecutive years after reaching the lowest value in 2016, and hit a record of nearly 10% in 2019. The highest record in the past 10 years; the dimension of scientific construction has fluctuated in the past 10 years, and also reached the highest value in 2019; compared with the above three indicators, the resource efficiency and people's livelihood development basically showed an upward trend year by year, indicating that in the process of Puyang's economic transformation, The quality of development in terms of resources and people's livelihood is good.

Based on the above analysis, here are some suggestions on how resource-based cities (especially Puyang) can achieve high-level development:

- 1) Actively implement policies related to people's livelihood (such as the social security system, etc.) to improve the stability and happiness of residents' lives.
- 2) Increase investment in science and technology to provide impetus for urban transformation.
- 3) Focus on the integrated development of economic benefits and ecological efficiency.

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