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Research on the Evaluation of Sustainable Development Capacity of Anhui Province Based on Data Envelopment Analysis

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Abstract

From the viewpoint of system theory, the coordinated development of five subsystems, including natural resources, environment, economy, society and population, is the basis of sustainable urban development. A Data Envelopment Analysis(DEA) model is established from the perspective of urban inputs and outputs to measure the sustainable development efficiency of Anhui cities from 2012 to 2020, and the results show that the sustainable development capacity of Anhui cities is not stable enough, and there are problems of low technological dependence and diminishing returns to scale. The key to improve the sustainable development capacity of Anhui province and city in the future is to use its ecological advantages to promote the optimization and upgrading of industrial structure, actively change the economic growth mode, and focus on innovation and education.

Keywords

Sustainable development capacity; Data Envelopment Analysis; Capability evaluation.

1. INTRODUCTION

A sustainable economic growth model refers to the unified and coordinated development of nature, economy and society. Initially this concept was only used in terms of the protection of the natural environment. Today, sustainable development has become a common concept for the whole world and all human beings, but how to realize the sustainability of economic development and social progress of resources, environment and human society still needs long-term and in-depth research and exploration in theory and practice.In terms of sustainable development evaluation index system, the evaluation methods include Environmental Sustainability Index (ESI), Ecological Footprint Method (EF), Energy Value Analysis (EmSI) and Sustainability Evaluation using Indicators (SEI) [1].Currently, one of the important methods for evaluating sustainability is principal component analysis (PCA) or data envelopment analysis (DEA) or a combination of both. From domestic research literature, Wu Yuying and He Xijun [2] used the DEA-CCR model to evaluate the sustainable development of Beijing from 1994 to 2003, using the number of employees, energy consumption, and environmental protection funds as input indicators, and the GDP and the consumption level of the city's residents as output indicators, and suggested that the development of circular economy is the key to enhance sustainable development;Zhang Yi and Wang Xianjia [3] evaluated the sustainable development of Hubei Province from 2001 to 2008 and proposed countermeasures using the FG model in DEA, using employees, fixed asset investment and energy consumption as input indicators and GDP and comprehensive utilization rate of industrial solid waste as output indicators;Qisong [4] used a DEA model to evaluate the efficiency of Shenzhen in terms of resource input, economy, and environmental conditions, and concluded that Shenzhen has the basis for sustainable development;Liu Liying [5] used energy, environmental pollution, labor and capital input as

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cost input indicators, and economic development, social development and people's life, and population development as benefit output indicators, and used the PCA-DEA method to evaluate Beijing's sustainable development capacity from 2000 to 2009.Xueyan Jiao [6] used the PCA-DEA method to evaluate the sustainable development capacity of cities in Henan Province.There are few studies on the evaluation of sustainable development capacity by means of DEA method, for this reason, this paper takes Anhui Province as the object of evaluation, based on the possibility and validity of data collection and data envelopment analysis as the evaluation model, with DEAP-2.1 as the technical support, and takes the time 2012-2020 as the decision unit, the decision unit is 9, the input indicators are Anhui Province local financial general budget income (billion yuan), local financial expenditure on environmental protection (billion yuan), the number of enrollment in general higher education (10,000 people), and the output indicators are per capita gross regional product (yuan/person) and per capita water resources (cubic meters/person). And the results are proposed to be adjusted accordingly.At the same time, the research idea of this paper also has some reference value for the investigation of the sustainable development capability of other industrial cities in China, and provides a model of ideas that can be operated. The data in this paper are mainly obtained from the official website of National Bureau of Statistics and Anhui Provincial Statistical Yearbook.

2. RESEARCH METHODOLOGY

Data envelopment analysis (DEA) Data envelopment analysis is a method used to analyze the relative efficiency of similar decision units and is a new area of research at the intersection of operations research, management science and mathematical economics.DEA is the use of mathematical planning models to evaluate the relative effectiveness (called DEA validity) among "departments" or "units" (called decision units, abbreviated as DMUs) that have multiple inputs and multiple outputs. The relative effectiveness of a "department" or "unit" (called a decision unit, abbreviated as DMU) with multiple inputs and multiple outputs (called DEA effectiveness).To determine whether a DMU is DEA-valid based on the data observed for each DMU is essentially to determine whether the DMU is located on the "frontier" of the set of production possibilities. The production frontier is a generalization of the production function in economics to the multiple output case, and the structure of the production frontier can be determined using DEA methods and models. When using DEA for efficiency evaluation of DMUs, a lot of management information with deep economic implications and context in economics can be obtained, thus, the research in the field of DEA has attracted many scholars.

The BCC model was proposed by Banker et al. in 1984, which is able to obtain the weights of inputs and outputs from the data itself and solve the problem of evaluating the efficiency of multiple inputs and multiple outputs. The model is based on the assumption of variable returns to scale (VRS), which separates "technical efficiency" from "scale efficiency" and is called "pure technical efficiency".The BCC model contains n decision units, each with m inputs and q outputs.θ^* is the optimal solution of the model, which represents the efficiency value, so the value range of θ^* is [0,1].The smaller the θ^*, the lower the efficiency, i.e., the more the amount of inputs can be scaled down.When a decision cell $\theta^* = 1$, the decision cell is on the production frontier (the production frontier is a data envelope of the production feasible set, indicating the lowest input combination that can be achieved without changing the existing output), indicating that there is no more room for equal proportional reduction of each input with constant output, and is in DEA effective state.A decision cell is DEA invalid when $\theta^*<1$, output remains the same, and there is still room for an equal reduction in inputs. By projecting the invalid decision unit onto the production frontier, the direction and amount of improvement in the input and output of the decision unit can be determined.

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In this paper, we select the input-oriented model in BCC and choose the time year as the decision unit to measure the input-output efficiency and evaluate the change characteristics of sustainable development capacity in Anhui Province using DEAP2.1 software.

3. RESULTS AND ANALYSIS

3.1. Evaluation index system construction and data Acquisition

The systems included in sustainable development are mainly resources, environment, economy and society.On the evaluation index system construction,Mostly, the level of efficiency of these systems is studied from different sides according to the actual situation of the country and region.In order to comprehensively and scientifically evaluate the sustainable development capacity of Anhui Province in recent years and to explore the problems in sustainable development,this paper combines the research results of previous authors and uses the BCC model in DEA to assess the sustainable development capacity of Anhui Province based on the criteria of comprehensiveness, scientificity and accessibility of data.The selection of data indicators was carried out from the following aspects.In terms of input, it mainly includes the general budget revenue of local finance in Anhui Province, the expenditure of local finance on environmental protection, and the number of enrollment of general higher education schools.In terms of output, gross regional product per capita and water resources per capita are selected as output indicators. According to the established evaluation index system, Anhui Province was selected as the decision unit for 2012-2020.The input and output data are collected and collated from the Anhui Statistical Yearbook, Anhui Statistical Bulletin and the government work report in previous years.

Table 1. 2012-2020 Anhui Province Sustainable Development Evaluation Index System Raw Data

Year	2020	2019	2018	2017	2016	2015	2014	2013	2012
Local fiscal general budget revenue (billion yuan)	3216.01	3182.71	3048.67	2812.45	2672.79	2454.3	2218.44	2075.08	1792.72
Local financial expenditure on environmental protection (billion yuan)	190.83	312.12	209.32	198.64	133.64	124.83	104.76	108.42	95.52
Enrollment of general higher education schools (ten thousand person)	41.25	40.08	30.7	30.72	30.74	32.65	31.03	29.66	28.62
Gross regional product per capita (yuan/person)	62411	60561	56063	49092	43686	39692	37580	34404	30697
Water resources per capita (m3/person)	2099.5	850.9	1328.9	1260.8	2018.2	1495.3	1285.4	974.5	1172.6

3.2. Data Envelopment Analysis Evaluation Results and Analysis

The evaluation results of the sustainable development capacity of Anhui Province from 2012 to 2020 were obtained (see Table 2)Since DEA analysis requires both inputs and outputs to be positive, the above composite scores are deflated upward by 2 units in this paper for DEA analysis.DEA results are valid if their combined efficiency is greater than or equal to 1, otherwise they are said to be DEA invalid.

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Table 2. 2012-2020 Anhui Province Sustainable Development Capacity Evaluation Results

Year	Comprehensive efficiency	Technical efficiency	Scale efficiency	Return to Scale
2020	1	1	1	constant
2019	0.985	0.988	0.996	increasing
2018	1	1	1	constant
2017	0.933	0.981	0.952	increasing
2016	1	1	1	constant
2015	0.934	0.949	0.984	increasing
2014	1	1	1	constant
2013	0.923	0.985	0.937	increasing
2012	0.966	1	0.966	increasing

Note: constant means constant returns to scale, increasing means increasing returns to scale

Anhui Province's sustainability is DEA effective in 2014, 2016, 2018, and 2020, i.e., its inputs and outputs are optimal, where technical efficiency and scale efficiency are both 1.The years 2012, 2013, 2015, 2017 and 2019 are DEA invalid, indicating that the sustainable development capacity of Anhui Province is at a low level in these years, with redundant inputs or insufficient outputs.Through the analysis of the results, the overall trend of comprehensive efficiency and pure technical efficiency first declined and then increased, with 2017 as a watershed, the comprehensive efficiency and pure technical efficiency from 2017 to 2020 showed an increasing trend, while the comprehensive efficiency and pure technical efficiency from 2015 to 2017 were generally lower than those before 2012, and there were large differences.The main reason may be the rapid development of China's economy before 2012 thus causing the development of resources in Anhui Province, with the continuous development of the market economy, to 2017 encountered greater market fluctuations, thus affecting the development of the following years.However, the data from 2019 to 2020 show that sustainability is gradually recovering. Since energy consumption, labor and capital investment not only rely on quantity, but also need scientific concepts and advanced technology to support, the government also needs to steadily improve investment year by year.

In general, the sustainability of Anhui Province over the past nine years has shown a certain volatility over time, showing a trend of decline, then rebound and then decline.In terms of the trajectory of sustainable development, the development of Anhui Province fails to coincide with the trajectory of sustainable development most of the time, and also shows a trend of weakening, indicating that the sustainable development capacity of Anhui Province is not stable enough, and there is still a big gap compared with the best development state.It needs to be enhanced by means of corresponding policies, institutional adjustments and technological innovations.

4. RECOMMENDATIONS FOR SUSTAINABLE DEVELOPMENT

4.1. Active transformation of economic growth, establishing a sustainable urban development system

Insist on "industrial enrichment", take the new road of industrialization, the organic combination of industrial structure optimization and upgrading, innovation-driven, from the management system, operation mode, talent utilization, scientific and technological innovation and other levels to enhance the internal electronic, mechanical, energy, materials, pharmaceutical industrial enterprises input and output level, the establishment of low consumption and efficient sustainable development of the city's industrial system.Take advantage of local advantages, "first rich" to drive the "later rich".Each city uses its own

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advantageous resources to give priority to its own development, and when one of its own cities becomes rich, then implement precise poverty alleviation, that is, to realize the development of mutual help between each city, using its own experience and policies to help the development of other cities.

In agriculture, we will take the road of agricultural industrialization and specialization, and vigorously develop ecological agriculture, urban agriculture, and provide high-quality agricultural products and agriculture-related service projects.We will practice energy conservation, optimize the use of resources, advocate a green economy, develop clean energy by taking advantage of our comparative advantages in the fields of solar energy, water energy and bioenergy, and continuously reduce waste emissions.Establish a long-term mechanism for environmental protection, standardize the investment of environmental protection funds, and improve the efficiency of the use of environmental protection funds. At the same time, make full use of "Internet+" tools to achieve the integration of the three industries.Enhance the sustainable development of cities in Anhui Province.

4.2. Effective skills training and vocational education, overall improvement of workforce employability

The increasing number of labor force has brought new tests to the urbanization process in Anhui Province.We should make full use of the State Council's "13th Five-Year Plan" to promote employment and the relevant human resources policies of provinces and cities.In view of the actual situation that Anhui Province undertakes the industries of developed regions and industry co-construction, we focus on providing comprehensive and efficient employment skills training and on-the-job training for the workforce in the "four new industries" such as new electronics, new energy, new materials and new medicine.Improve the productivity of the workforce by improving its employability and job skills.Meanwhile, we should increase the precise support for local middle and high vocational colleges and universities to cultivate various kinds of middle and high level skilled talents to meet the needs of the province's industrial economy optimization and adjustment.

4.3. Vigorously implement the innovation-driven strategy, improve the efficiency of urban development inputs and outputs

Promote technological progress and promotion efforts in various industries, effectively strengthen the construction of local talent teams and the introduction of high-level talents in Anhui Province, promote the free and efficient flow of various resources, release various development potentials through institutional innovation and technological progress at all levels, and enhance the efficiency of urban development investment and output.Implement an industrial concentration strategy. Concentration of industries not only allows the use of common infrastructure, but also facilitates communication between the same industries and helps to promote the development of the industry.

4.4. Focus on scale adjustment, reduce input redundancy

Non-effective scale efficiency directly leads to ineffective overall aggregate technical efficiency, and excessive scale of investment is counterproductive.More attention should be paid to the rational allocation of inputs and existing resources in industrial development, continuously improving the allocation efficiency of resources and coordinating the harmonious development of economic, social and ecological systems.The importance of improving the efficiency of resource utilization must be given priority.Vigorously develop circular economy, reduce environmental pressure, optimize industrial structure, and learn from the successful experiences of other regions.Actively support the development of new industries,promoting sustainable development capacity with continuous industrial progress.

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