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Empirical Study on the Impact of Environmental Protection Technology Investment on Urban Water Pollution Control Efficiency Based on Smart City Construction

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Abstract: *In recent years, with the rapid development of science and technology, the construction of smart city has entered a new climax. But at the same time, due to the construction of smart city is still in the initial stage, there is no unified standard at home and abroad, so that the specific implementation process often leaves deficiencies, such as the more prominent problem of urban water pollution control efficiency. However, the research on this aspect is still blank in China. Therefore, this paper puts forward an empirical study on the impact of environmental protection technology investment based on smart city construction on urban water pollution control efficiency. This paper studies the core concepts of smart city construction and urban water pollution control. In order to improve the efficiency of water pollution control, we must establish a set of objective and scientific evaluation index system and matching efficiency calculation method. Therefore, this paper innovatively puts forward the empirical method of investment efficiency of environmental protection science and technology for water pollution control in smart city. Based on the current situation of smart city construction, this method classifies the factors that affect the efficiency of water pollution control, and optimizes the calculation method of empirical model. The optimized empirical model can be applied to smart cities with various economic structures, and is not limited by the size of the city, which can maximize the applicability of the model. In order to verify the actual effect of the empirical method, this paper takes Chongqing as the test object, and collects the data of the city in recent five years as the experimental sample. Through the analysis of the results of empirical tests, it can be seen that the test method of water pollution control efficiency in this paper has high accuracy, and can play an important role in water pollution control of smart city construction.*

Keywords: *Smart City Construction, Water Pollution Control, mpirical research, Investment in Environmental Protection*

1. Introduction

"Smart city" is a smart way to make city life better. For example, new technologies such as cloud computing and Internet of things have changed the communication between enterprises, government and people. The city's environmental protection, service, public safety, people's life and other needs can be quickly responded to, and the city's operation efficiency can be improved. With continuous development information society, smart city construction has become the main way for major cities to promote the development of emerging industries and seize the commanding heights of information technology. The construction of smart city is clearly described in "several opinions of the State Council on promoting information consumption and expanding domestic demand" and "national new urbanization plan (2014-2020)"; the "guiding opinions on promoting the healthy development of smart cities" jointly issued by the Ministry of industry and information technology puts forward the goal of building a number of smart cities with distinctive characteristics by 2020. In 2015, Li Keqiang also

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mentioned the need to actively build smart cities in the relevant government work reports. It can be seen that the construction of smart cities has become the trend of urban development in China in the future. However, due to the rise of smart city construction wind, it also leads to many urban construction problems, such as environmental protection and urban water pollution control and other practical management problems. Therefore, in order to build and promote the development of smart city, it is necessary to establish an efficient and objective evaluation system to compare and measure the final effect of construction. In addition, as an effective means to ensure the healthy development of smart city, smart city assessment needs to be implemented in all stages of smart city construction, planning and operation, so as to realize the real significance of the assessment.

China's per capita water resources share is only 1 / 4 of the world's per capita level. With the acceleration of the construction process of smart cities, people's living standards are constantly improving, water consumption is increasing significantly, and the problem of water shortage is becoming increasingly prominent. At present, more than 400 cities in China are short of water. In normal years, cities are short of water by 6 billion cubic meters and 16 million cubic meters a day. It is estimated that after 2010, China will enter a period of serious water shortage, and the water shortage will reach 40-50 billion cubic meters by 2030. At the same time, the shortage of water resources is becoming more and more serious. The discharge of urban sewage not only causes water pollution, but also intensifies the tension of water resources. According to statistics, in 2005, China's urban sewage discharge reached 41.4 billion cubic meters, most of which were discharged into rivers, lakes and oceans without effective treatment. More than 90% of China's urban water bodies are polluted to varying degrees, and nearly 50% of the centralized drinking water sources in key cities and towns do not meet the water intake standards. Therefore, urban water pollution control has become an important issue in the development process of China. Although great progress has been made in urban water pollution control in China in the past 20 years, there is still a big gap compared with the developed countries in the world. Although the government has invested a lot of manpower, material and financial resources in the treatment of urban water pollution, so far, the treatment effect is not good. Due to the influence of planned economy, the current urban water pollution control in China has not completely got rid of the traditional ideas and methods, and is still constructed, managed and operated by the government independently. It is not in line with the operation law of market economy and lacks reasonable operation mechanism and project management mode, which cannot meet the needs of urban development. Therefore, this paper puts forward the empirical research on the impact of environmental protection technology investment on urban water pollution control efficiency based on the construction of smart city, all of which are to improve the water pollution control ability in the construction of smart city in China.

First of all, this paper studies the core concepts of smart city and urban water pollution control. Through the research, this paper believes that the development of smart city is the main trend of urban development. After years of practice, the governance effect of smart city on urban management has been shown, but the existing construction of environmental protection technology investment in urban water pollution is insufficient, resulting in different water pollution treatment effects. In view of the current situation of water pollution control in smart cities in China, this paper establishes a new empirical research method for investment efficiency of water pollution control in smart cities. The core technology of this method is to reconstruct the evaluation system of water pollution treatment efficiency according to the actual situation of smart city. In the introduction of the system, this paper gives the design principle and the necessity of index setting. According to the index system, an empirical model is established. The algorithm of this model optimizes the calculation method, simplifies the calculation steps, and quantifies the investment index of environmental protection science and technology, and effectively calculates the efficiency of the index for urban water pollution control. In order to further verify the actual effect of the empirical model in this paper, at the end of the study, this paper establishes a comprehensive test with a city as the experimental sample. Through multiple tests including comprehensive efficiency analysis, pure technical efficiency and scale efficiency analysis, and multicollinearity test, we can see that the empirical method in this paper has good comprehensive performance, and has passed multiple test standards including multicollinearity test and independent variable correlation test [1-3].

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2. Core Concepts of Smart City and Water Pollution Control

2.1. Concept of Smart City

After the concept of smart city was put forward, the active application of the world's major cities makes the smart city flourish in the world. The rapid development of smart city has aroused great interest of relevant scholars, who try to interpret smart city from different perspectives. Because smart city is a new concept after all, its development time and research time are not too long, and the theoretical circle has not reached a consensus.

Some scholars have given the answer from the technical level. They think that smart city is a perceptual city system formed by setting up a large number of sensors and connecting through the Internet. By collecting the information of each sensor, forming data information, through the analysis and processing of cloud computing technology, the city can make intelligent decisions on various behaviors of the city. From this perspective, technology is the core of smart city, and technology is the driving force of smart city. However, this view often ignores the function and cultural attributes of the city, and only analyzes it from the technical level.

Some scholars have given the answer from the connotation of smart city. They think that smart city is to use emerging technologies to change urban operation mode, improve the efficiency and connotation of urban services, comprehensively coordinate the balanced development of urban politics, economy and culture, and realize the wisdom of urban services. This view pays more attention to human factors and the living needs of urban residents, but often ignores the ability to realize technology, reflecting people's better vision for urban development [4-6].

2.2. Connotation of Smart City

Smart city is the local embodiment of smart earth and the inevitable product of urban informatization development to a higher stage. In a sense, smart earth and smart city reflect a contradiction, that is, the contradiction between the tighter, smoother and smaller world brought about by the rapid development of the information world and the backwardness of our urban management. So, we need to use new technologies to improve human management of the world. Smart city will change our living environment and greatly affect our lifestyle. In essence, smart city is a kind of new thinking, new mode and new form of developing city, governing city and perfecting society. It is the innovative achievement of intelligent technology in social management, economic development and human life. On the basis of carefully reading the literature in this field and combining with the typical practice analysis of smart city, the concept of smart city is embodied in two aspects

(1) Healthy and sustainable development of economy

Smart city economy is a green economy based on the concept of sustainable development. Compared with the traditional economic growth mode of high consumption and high cost, the economic development pays more attention to the environmental carrying capacity and improves the efficiency of resource utilization. On the other hand, we should strengthen the recycling of existing resources, build a good economic cycle model, improve economic efficiency, and form a high-speed and benign economic growth. By changing the traditional extensive growth mode, smart city seeks a new and long-term way out to solve the three major problems of people's livelihood project, urban modern management and urban economic sustainable development.

(2) Life is more comfortable and convenient

It is the realization of the harmony between human beings and things, between human beings and things, and even between human beings and human beings. In addition, smart city will penetrate services into health, medical, transportation, leisure and other life fields through high-end technology and intelligent management, and human life will enjoy unprecedented convenience [7-9].

2.3. Concept of Environmental Protection Investment

There is no consensus on the definition of environmental protection investment at home and abroad, including cost theory and investment theory.

According to the cost theory, environmental protection investment the total cost of pollution prevention and improvement paid to maintain the social environment and burden social development. It

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mainly includes the cost of environmental protection, the social loss caused by environmental damage, and the management or operation cost of environmental management, mainly represented by the United States and Japan, which is mainly related to the concept of western developed countries sacrificing environment and natural resources to promote economic and social development in the process of economic development. As the western developed countries usually adopt the way of "end treatment", environmental protection investment is mainly used to prevent and control the consequences of environmental pollution and environmental damage.

According to the investment theory, environmental protection investment is not only to prevent pollution and protect the environment, but also for the sustainable development of economy. It is an indispensable part of social fixed assets investment. This part of scholars divides environmental protection investment into industrial pollution control investment, urban infrastructure investment, environmental pollution maintenance and improvement investment, environmental management service investment and so on. In the process of economic development, various funds are used for the prevention and control of environmental pollution and the protection of ecological environment [10-12].

2.4. Investment in Environmental Protection Technology

In the 21st century, the key to meet the challenge is science and technology, "science and technology is the first productive force". Comrade Deng Xiaoping has long put forward the concept that science and technology are productive forces and the first productive forces. Science and technology investment refer to the investment in various scientific and technological activities, which is a kind of productive investment. By 2012, China's R & D financing scale exceeded trillion yuan for the first time, ranking the third in the world.

In a broad sense, science and technology input refers to all the resources used to support the development of science and technology activities, including human resources, material resources, finance, government support and related technology investment. In a narrow sense, it refers to the total amount of funds invested in basic research, applied research and experimental development. Science and technology investment need to create new knowledge by scientific methods. Basic research usually refers to exploring the nature of observable facts or phenomena through experimental means or theoretical reasoning, so as to obtain new knowledge. It is mainly aimed at a specific practical purpose or goal, and has concrete nature. Experimental development refers to a series of or more systematic work carried out by researchers on the basis of basic applied research or practical experience in order to acquire new knowledge, produce new equipment, new materials or new products, establish new service processes and improve existing technologies. The development of any industry needs the support of science and technology. As a strategic emerging industry, environmental protection industry needs more scientific and technological support. Science and technology investment in environmental protection industry should be more urgent [13-15].

2.5. Concept of Environmental Pollution Control Efficiency

To define the concept of environmental pollution control efficiency, we must first clarify the connotation of efficiency. The concept of efficiency is different in different fields. The application of efficiency first appears in engineering discipline, and then it is widely used in other fields, such as economics and management. In each field, the ratio of input-output refers to the time of management. Through effective management, we can improve the efficiency of resource utilization and reduce the cost of resource consumption. The way to improve efficiency lies in the orderly allocation of resources. No matter in which field, the root cause of efficiency improvement is the same, because of the contradiction between unlimited demand and limited resources.

In the field of environmental pollution control, due to the scarcity of environmental resources and the limitation of government financial resources, it is particularly necessary to improve the efficiency of pollution control. In this paper, the efficiency of environmental pollution control mainly refers to the proportional relationship between input factors and output factors in environmental pollution control activities. According to different research perspectives, the efficiency of environmental pollution control refers to how to reduce input under the condition of constant output scale. The efficiency of environmental pollution control refers to how to get more output under the same input factors. This paper focuses on the pollution control input, evaluates the efficiency of water pollution control, and discusses how to optimize the utilization of input resources under a certain output scale. In the process

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of water pollution control, human resources, financial resources and equipment investment are taken as input projects in the treatment process, and the output indicators of water quality improvement and treated waste water volume are used to evaluate the effect of water pollution control [16-17].

2.6. Operation Mechanism of Traditional Urban Water Pollution Control

As a public welfare undertaking of environmental protection and ecological construction, urban water pollution control has been fully invested in construction, operation and management by the state in the past. With the smooth transition from planned economy to market economy, the traditional urban water pollution control mechanism cannot meet the requirements of market economy.

Taking the sewage treatment plant as an example, the urban sewage treatment plant is an important participant in the sewage treatment process. The problems in the operation process typically reflect the problems existing in the traditional urban water pollution control and operation mechanism. In the past, the investment subject of urban sewage treatment facilities was limited to the government, and the management and operation were almost directly operated by the government. On the one hand, the investment channel is single and the fund is seriously insufficient. On the other hand, it will also lead to the lack of political affairs and unclear separation of responsibilities of operation and management, and the development of sewage treatment plant lacks vitality. It leads to low investment efficiency, seriously hinders the development of sewage treatment market, and restricts the formation of a good sewage treatment and recovery investment and operation mechanism.

At the same time, the government's management of urban water pollution control is relatively backward. In the process of urban sewage treatment, urban industrial wastewater monitoring is managed by environmental protection department, and urban sewage treatment is managed by urban construction department. In particular, the drainage network and sewage treatment plants in some cities belong to different management departments. In addition, the utilization of reclaimed water involves water resources management, health and agriculture, which brings certain difficulties to the management of urban sewage treatment and use [18-20].

3. Research Hypothesis

The governance efficiency of urban water pollution is affected by many factors, and for all cities, the construction degree of smart city and investment in environmental protection are also different. In the face of many complex factors, it is difficult to say that one factor has played a particularly important role, and the impact of these factors on the final urban water pollution control efficiency is not independent. Theoretically speaking, the construction of smart city will inevitably involve investment in environmental protection, and for environmental protection investment, it includes pure technology investment and scale investment. Both of them play an important role in the final urban water pollution control, which should be a positive proportion relationship, that is, the more investment, the higher the final urban water pollution control efficiency. If the test results are true, it can be judged that the more investment in environmental protection technology in the construction of smart city, the higher the efficiency of urban water pollution control. This paper takes this as a research hypothesis, and as an important basis to judge the water pollution control ability of smart city.

4. Sample Selection

The data of this study is from Chongqing, which has carried out more than 5 related construction work of smart city, and the main function of smart city has been initially reflected. The data from 2017 to 2021 are selected as samples, and the data information is processed by dimensionless processing, as shown in Table 1.

Table 1: dimensionless data list

Particular Year	Comprehensive Efficiency	Technical Efficiency	Scale Efficiency	Returns To Scale
2017	0.7632	0.6821	0.7425	Drs
2018	0.8254	0.7251	0.9114	Drs
2019	1.0000	1.0000	1.0000	-
2020	0.9215	0.7962	0.8245	Drs

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2021	1.0000	1.0000	1.0000	-

5. Research Method

5.1. Construction Principles of Evaluation System

(1) Scientificity

When evaluating the investment efficiency of water pollution control, we should analyze the logical structure of governance according to certain scientific theory and corresponding evaluation index system, and also refer to the governance principles of relevant links. Secondly, grasp the essence of the project and select the most valuable analysis index. Finally, it is necessary to use a certain mathematical model for rigorous reasoning in order to accurately reflect the investment efficiency of water pollution control.

(2) Systematicness

The investment benefit evaluation system of water pollution control is a system, that is to say, the overall level of the project should be considered in the evaluation, and the selection of indicators should be analyzed and considered from all aspects and links according to the relevant actual situation. At the same time, each index should have obvious hierarchical correlation, there should be no overlap and contradiction between the upper and lower indicators, and the indicators at the same level should have certain correlation and complementarity.

(3) Representativeness and conciseness

A variety of indicators can be selected to represent the investment efficiency of water pollution treatment, and reasonable selection can be made according to the needs. However, if the number of indicators is too large and too chaotic, it is difficult to carry out effective evaluation. And will make the evaluation process cumbersome, unable to meet the requirements of the evaluation results. In order to make the evaluation system work, the selection of index system should not be too complicated, but should be reasonably simplified and a representative value should be selected.

5.2. Dimension Selection of Water Pollution Control Performance Measurement

The establishment of water pollution control evaluation system and evaluation index system in China has been in the exploratory stage. In addition, the evaluation of water pollution treatment in the past often focused on chemical indicators. This study will build an index system from three dimensions of environmental performance, economic performance and social performance of water pollution control.

(1) Environmental performance

At present, the water quality in many areas of China does not meet the drinking water standards, and rural domestic sewage is generally discharged into rivers without treatment. The use of pesticides and fertilizers has not been controlled. Industrial and mining enterprises wantonly discharge waste water, causing obvious pollution to the environment. Environmental benefits emphasize the quality control of water environment, that is to solve the problem that most water quality does not meet the drinking water standards.

(2) Economic performance

The control of water pollution will bring about the improvement of ecological environment and the growth effect of Commerce and tourism. Many factors need to be considered in the analysis and treatment. On this basis, some related pollution control technologies and methods are developed, which play a leading role in the local materials, energy technology and other industries.

(3) Social performance

The treatment of water pollution is related to the vital interests of the public. Long term drinking of polluted water will cause various diseases and affect people's living standards. The direct beneficiaries of water pollution control are the general public. As direct consumers of water, they can improve the quality of water environment [21-22].

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5.3. Empirical Model

From the perspective of environmental protection investment, this paper uses panel data model to study the impact of environmental protection investment on water pollution control. In order to avoid and alleviate the multicollinearity and heteroscedasticity of the equation, the following models are constructed by using the funds from different regions in the form of logarithmic transformation

$$indw_{i,t} = \beta_0 + \beta_1 souin_{i,t} + \beta_2 gpi_{i,t} + \beta_3 \ln rd_{i,t} + \beta_4 hydin_{i,t} + \beta_5 is_{i,t} + \varepsilon_{i,t} \tag{1}$$

Among them, $indw_{i,t}$: urban wastewater pollution discharge

$souin_{i,t}$: investment level of environmental protection

$gpi_{i,t}$: progress level of environmental protection products

$\ln rd_{i,t}$: research funding level

$hydin_{i,t}$: Fixed assets investment in water pollution control

$is_{i,t}$: Industrial structure

$\varepsilon_{i,t}$: error term

i And n represent each region, and $\beta t(t = 0,1,2,3,4,5)$ is the parameter. The positive and negative sum of the parameters indicates the degree and direction of the influence of the explanatory variables and control variables on water pollution control.

5.4. Dimension Selection of Water Pollution Control Performance Measurement

According TO the scientific, integrity and guiding principles, according to the actual situation, the evaluation index system of water pollution control efficiency is divided into input index and output index.

(1) Input indicators, this paper studies the effectiveness of water pollution control, environmental pollution control cost indicators mainly include human input, material input and financial input.

1) People are the main body of environmental pollution control. According to the characteristics of water pollution control in China, there is no direct number of sewage treatment personnel. The number of employees in the water conservancy, environment and public facilities management industry (at the end of the year) is an indicator of human resources input by urban units in different regions. Therefore, the number of employees in water conservancy, environment and public facilities management industry is selected as the human resource index.

2) Capital investment is the most important factor in water pollution control, and the amount of investment is closely related to the efficiency of water pollution control. The financial investment of water pollution control mainly includes two parts: one is the total investment of environmental pollution control. According to the main body and purpose of environmental protection investment, water pollution control investment can be divided into two parts: sewage treatment investment of urban environmental infrastructure construction and sewage treatment investment of industrial pollution source. Sewage treatment investment of urban environmental infrastructure construction is the investment of government to urban domestic sewage.

3) In this paper, the treatment capacity of sewage treatment equipment is selected to represent the material input, and the treatment capacity of industrial sewage treatment facilities and the sewage treatment capacity of urban sewage treatment plants are selected as two indicators.

(2) The output index reflects the effect of water pollution control. According to the actual situation of Shanxi Province and the availability of data, this paper selects the output index from two aspects.

1) The most obvious effect of water pollution control is the improvement of water quality. Improving the surface water quality is the research direction of this paper. The proportion of good water quality (I - III) in the main monitoring section is selected for measurement.

2) Sewage treatment, sewage treatment capacity directly reflects the situation of sewage treatment. Industrial wastewater treatment capacity and urban sewage treatment capacity are selected to represent the treatment status of industrial wastewater and domestic sewage. The specific index system in this paper is shown in Table 2.

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Table 2: index system of water pollution control efficiency

Primary indicators	Secondary indicators	Third level index	Indicator symbol
Input index	Manpower input index	Number of employees in water management industry	ten thousand people
	Financial input index	Investment in treatment of pollution source wastewater	Ten thousand yuan
		Investment in sewage treatment	Ten thousand yuan
		Operation cost of sewage treatment facilities	Ten thousand yuan
	Material input index	Treatment capacity of sewage treatment facilities	10000 tons / day
		Treatment capacity of municipal wastewater treatment plant	Ten thousand cubic meters / day
Output indicators	Water quality standard rate	Proportion of class III standards	%
	Wastewater treatment capacity	Sewage treatment capacity	10000 tons
		Urban sewage treatment capacity	Ten thousand cubic meters

5.5. Data Processing

In the process of practical problem modeling, especially in the process of establishing index evaluation system, different types of data processing and fusion are often faced. However, due to different measurement units and orders of magnitude, these indicators are not comparable, so it is usually necessary to standardize the data before data analysis. Although the evaluation method has no specific requirements on the dimension of input and output data, there are great differences between different sample data. Direct use of the model will reduce the accuracy of the evaluation results, so it is necessary to deal with the original data dimensionless. The specific transformation method is as follows:

$$y_{ij} = 0.1 + \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} * 0.9 \tag{2}$$

For the variable y_{ij}, $i = 1,2,\ldots,10$ is the number of variables and $j = 1,2,3,\ldots,630$ is the number of samples. Through dimensionless processing, each index is converted into data between 0 and 1, which not only meets the requirements of the evaluation method, but also solves the negative value problem of input and output indicators, and does not affect the evaluation results of the model.

5.6. Dynamic Evaluation Method

The model can only be used to evaluate the efficiency of water pollution control in the same period, while the environmental protection input index can reflect the change of water pollution control efficiency in the same period and adjacent periods. In this paper, the model is combined with total factor productivity index to measure the efficiency of urban water pollution control. At the beginning, environmental protection investment was used as a measure of productivity change. The combination of environmental protection input index and data envelopment method expanded the application scope of environmental protection investment. Total factor productivity index is divided into two parts, one is technical change, the other is technical efficiency change. The change of technical efficiency can be divided into pure technical efficiency change and scale efficiency change. If the change of pure technical efficiency is greater than 1, the productivity will increase, and the change of scale efficiency is greater than 1, indicating that the scale converges to the optimal scale. The specific index formula is shown in formula (3) [23-25]:

$$TFP_i^{t+1}\left(y^{t+1}, x^{t+1}, y^t, x^t\right) = \frac{D_t^{t+1}\left(y^{t+1}, x^{t+1}\right)}{D_i^t\left(y^t, x^t\right)} \left[\frac{D_i^t\left(y^{t+1}, x^{t+1}\right)}{D_i^{t+1}\left(y^{t+1}, x^{t+1}\right)} \bullet \frac{D_i^t\left(y^t, x^t\right)}{D_i^{t+1}\left(y^t, x^t\right)}\right]^{1/2} \tag{3}$$

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6. Empirical Test and Analysis

6.1. Comprehensive Efficiency Analysis

Comprehensive efficiency is mainly used to reflect the change of annual efficiency, that is, it can reflect the utility of input relative to output. It can be seen from the analysis in Figure 1 that the annual efficiency changes greatly from 2017 to 2021, with the maximum value of 1, the minimum value of 0.7632, and the average value of 0.9020. According to this result, only 9.8% of the input elements have been wasted in the past five years. In other words, under the same conditions, the investment funds have not yet reached the level of effective utilization. Among them, the comprehensive efficiency, pure technical efficiency and scale efficiency all reach 1, that is, the effective period of efficiency is 2019 and 2021, which indicates that the investment efficiency in these two years is the highest, which is more effective than other years. This can also be explained by the fact that the utilization rate of resources in the past three years is the highest in terms of technology and scale, and there is no waste.Comprehensive efficiency

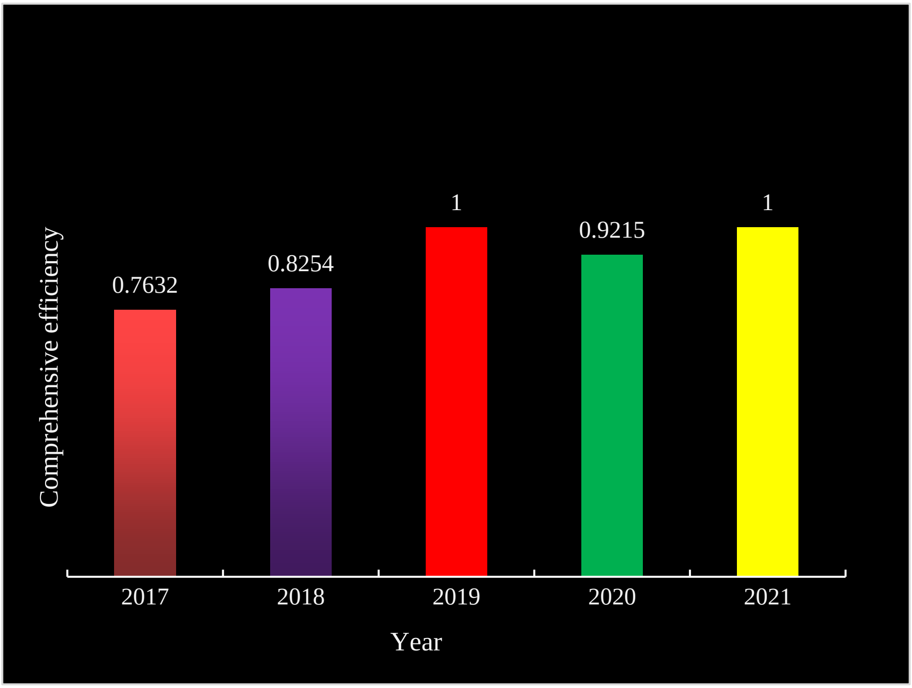

Figure 1: analysis of comprehensive efficiency test results

6.2. Analysis of Pure Technical Efficiency and Scale Efficiency

As can be seen from the analysis results in Figure 2, from the pure technical efficiency, the highest investment efficiency is 1, the lowest is 0.6821, and the average is 0.8406. From the perspective of scale efficiency, the average efficiency of five years is 0.8956, the minimum is 0.7425, and the maximum is 1. In the years when the comprehensive efficiency is invalid, the pure technical efficiency is 1, which indicates that the low efficiency of comprehensive efficiency is caused by the low efficiency of scale. Therefore, it is necessary to consider expanding or reducing the scale of investment to make it relatively effective. The remaining four years are ineffective not only in terms of technical efficiency, but also in terms of scale. This shows that we should adjust the scale of investment, improve the level of technology, and make the input-output match the scale.

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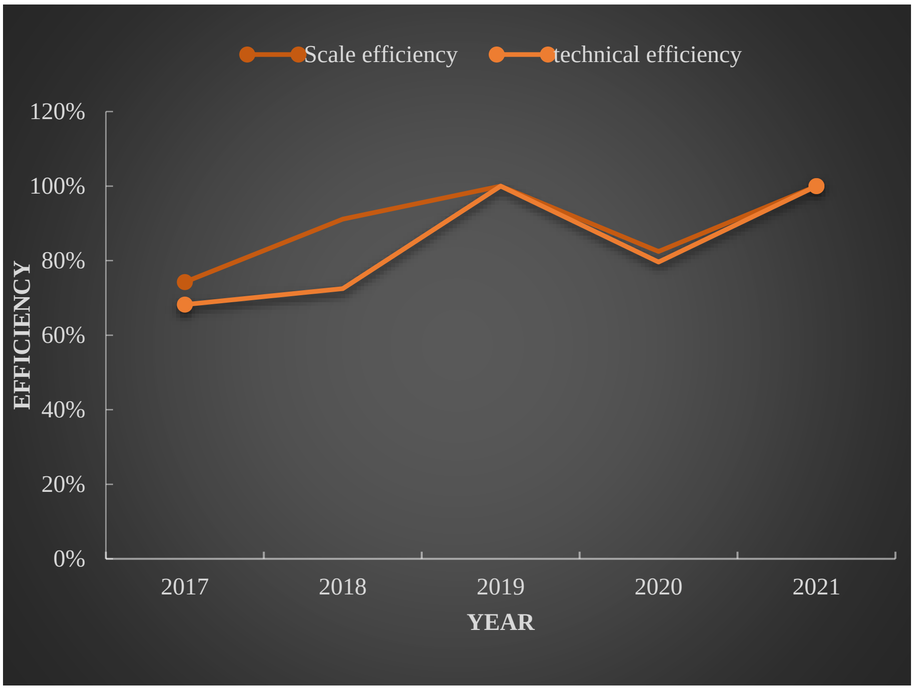

Figure 2: Analysis of test results of pure technical efficiency and scale efficiency

6.3. Multicollinearity Test

Since the panel regression cannot obtain the collinearity statistics such as tolerance and variance spread factor (VIF), this paper uses the linear regression model to evaluate the problem and test whether there is multicollinearity. According to the rule of thumb, the larger the VIF, the more serious multicollinearity. The maximum VIF should not exceed 5. According to the test results in Figure 3, the maximum value of VIF is 2.26, the minimum value is 0.89, and the maximum value is far less than the standard value of 5. Therefore, the model in this paper has passed the multicollinearity test.

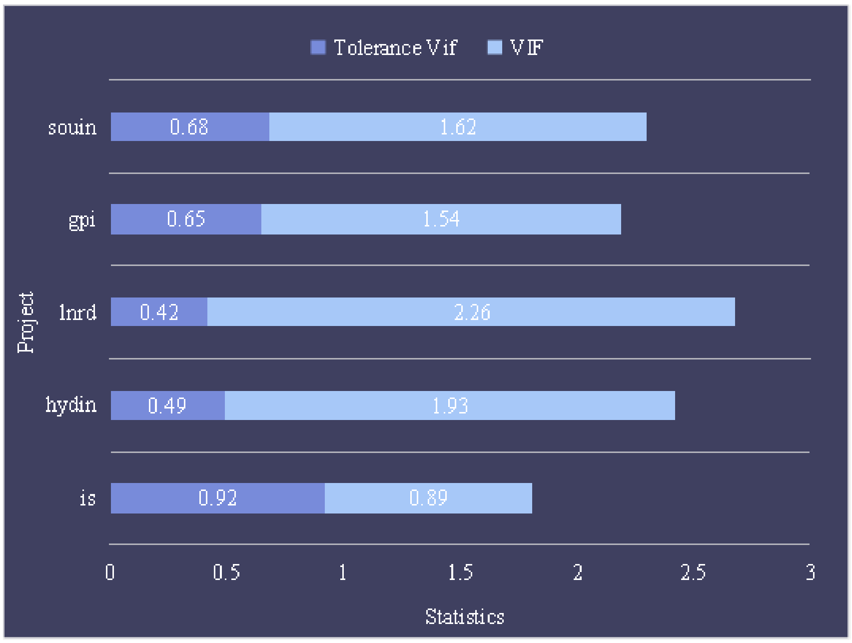

Figure 3: Multicollinearity test results

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6.4. Correlation Test of Independent Variables

In this paper, the correlation between independent variables is tested, and the correlation coefficient matrix is tested. From the statistical analysis results in figure 4, it can be seen that the correlation coefficients among the variables are all below 0.5, but the correlation coefficients of individual variables are higher (the correlation coefficient of lnrd and hydin is 0.5432, and that of lnrd and souin is 0.5421). There is no clear standard for the relationship between correlation coefficient and collinearity, which indicates that there is no serious multicollinearity problem in the model.

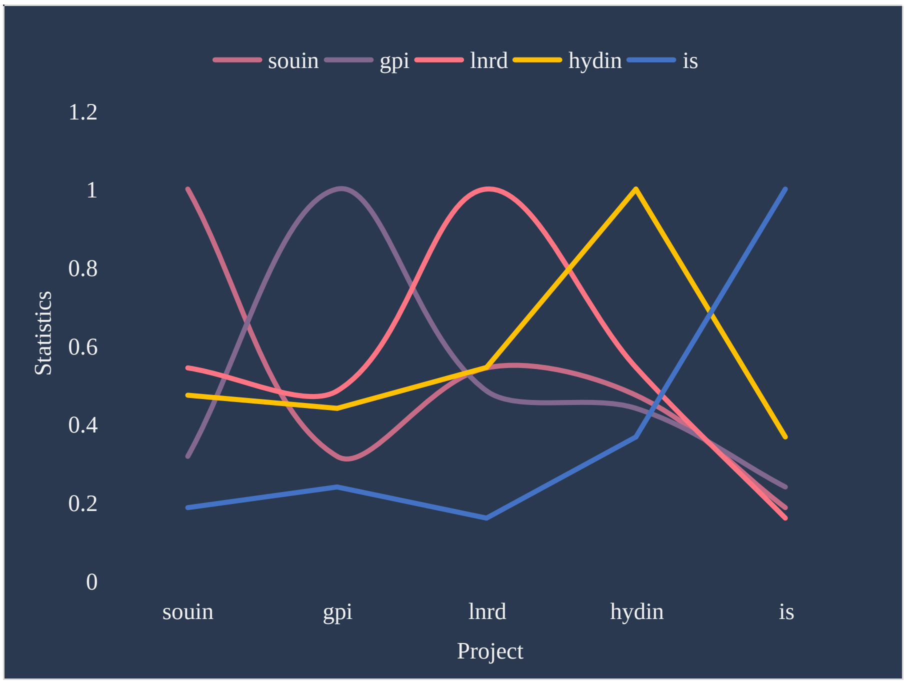

Figure 4: analysis of correlation test results of independent variables in empirical model

7. Conclusions

How to effectively improve the efficiency of urban water pollution control is one of the core issues in urban management and smart city construction. But at present, there is little research on this aspect, and the mainstream research focus is still concentrated on the urban industrial structure and the informatization construction of smart city. The lack of research in the field of environmental protection is a common problem in the construction of most smart cities. Therefore, the empirical research on the impact of environmental protection technology investment based on smart city construction on urban water pollution control efficiency proposed in this paper has played a role in making up for the deficiencies in this field to a certain extent. In order to more objectively reflect the effect of environmental protection technology investment on water pollution control in the construction of smart city, this paper reestablishes a set of new index evaluation system, and the dimension selection of water pollution control performance level is more in line with the actual objective situation. By optimizing the structure of the empirical model, simplifying the calculation method, and combining with the dynamic evaluation method, a complete efficiency detection system is formed. At the end of the study, the practical effectiveness of the method is further verified by comprehensive efficiency analysis, pure technical efficiency and scale efficiency analysis, and multicollinearity test.

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