The Impact of Digital Economy on the Upgrading of Industrial Structure in Resource-depleted Cities in China
——Empirical Analysis Based on Data from 23 Provincial Panels in China

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Abstract
Limited by its own development law, the development of resource industries and resource-based cities will inevitably go through the process of construction, prosperity, decline, transformation, revitalization or demise. How to carry out economic transformation and find a new way out is a difficult problem facing resource-depleted cities. With the accelerated penetration of digital technology, goods and services into traditional industries, the digital economy has become a new engine driving China's economy to achieve good and rapid growth. In this paper, taking the industrial structure level of resource-declining cities as the research object, the gray correlation degree is used to conduct empirical analysis of the data of 23 provincial panels, digital infrastructure, digital industrialization and industrial digitalization are selected as the core explanatory variables, and the level of economic development, government intervention and foreign trade are introduced as control variables. However, compared with other types of cities, the influence of Internet penetration indicators in this type of city is generally low. According to this conclusion, corresponding countermeasures and suggestions are proposed to improve the process of industrial structure transformation and upgrading of resource-declining cities.

Keywords-*resource-depleting cities; industrial structure level; digital economy; gray correlation*

1. INTRODUCTION

In recent years, the digital economy has developed rapidly and has become a key force in the reorganization of global factor resources, the reshaping of the global economic structure, and the change of the global competitive landscape. Digital technology has been fully integrated into all fields of human society and the whole process of production. General Secretary Xi Jinping attaches great importance to making the digital economy bigger and stronger, and emphasizes the need to give full play to the leading role of informatization in economic and social development. During his inspection in Anhui, President Xi Jinping stressed that it is necessary to deeply grasp the new characteristics and new requirements of the stage of development, grasp the transformation and upgrading of traditional industries on the one hand, and the development and growth of strategic emerging industries on the other hand, promote the accelerated development of the manufacturing industry to digitalization, networking and intelligence, and improve the stability and modernization level of the industrial chain supply chain[1].

According to the National Sustainable Development Plan for Resource-based Cities (2013-2020) there are 67 resource-declining cities [2]. They are facing problems such as resource depletion, lagging economic development, and prominent problems in people's livelihood, and they are also key and difficult areas for accelerating the transformation of the mode of economic development. In order for resource-based cities to change their excessive dependence on natural resources and get rid of the problem of "resource-rich cities thriving and resource-depleted cities declining", it is necessary to carry out economic and industrial transformation [3].

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In many studies, the integration and development of the digital economy and traditional industries has an important role in achieving industrial transformation and upgrading. For resource-depleted cities, how to use the opportunity of the digital economy to integrate traditional industries with new energy technology, Internet technology and intelligent manufacturing, etc., and as the development focus of the transformation and upgrading of resource-depleting urban industries, is of great research value.

In this paper, the industrial structure level of resource-depleted cities is taken as the research object, and 23 resource-depleted cities are selected Provincial panel data, the upgrading of the industrial structure of resource-depleting cities is regarded as the process of systematic evolution, the internal mechanism and basic path of the digital economy affecting the upgrading of the industrial structure of resource-depleting cities are theoretically analyzed, and the effect of the digital economy on the upgrading of the industrial structure of resource-depleting cities is empirically tested by the grey correlation method, and on this basis, the ideas and policy suggestions for developing the digital economy to promote the upgrading of the industrial structure of resource-depleting cities are proposed[4].

2. LITERATURE REVIEW

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2.1. Overview of the Digital Economy

The rapid development of the world's digital economy has led to the rapid growth of the world economy. The latest statistics show that the contribution of the digital economy to global gross domestic product (GDP) can be as high as 22.5%. Many scholars at home and abroad have studied the development of the digital economy from different perspectives. The concept of the "digital economy" was first proposed by Don Tapscott in his book Digital Economy: The Promise and Crisis of the Age of Cyber Intelligence, which he believes is the concept of combining intelligence, knowledge and creativity to achieve breakthroughs, wealth creation and social development. Other scholars' early definitions of the "digital economy" generally focused on the Internet, and later added new technologies. But the concept of the "digital economy" has not been conclusive. In China, the definition of "digital economy" at the 2016 G20 Summit is generally adopted. According to the combing of the concept of digital economy, two common characteristics of the digital economy are summarized: one is the ICT products and services in the digital economy, which basically include telecommunications; the other is the recognition of the blurred boundaries of the digital economy [5].

2.2. An Overview of the Industrial Situation of Resource-declining Cities

The industrial situation of resource-declining cities is not optimistic, and they mainly face the following dilemmas: First, with the depletion of resources, the resource and environmental foundation of urban development is in crisis. Second, the location conditions of resource-depleting cities are poor, the urban economic system is in a relatively closed state, the dependence on the leading resource industry is strong, and there is a lack of space for independent operation. Third, the industrial structure is single, the urban function is incomplete, the development is limited, and the alternative industry has not yet been formed. Fourth, the total economic volume is insufficient, the local financial resources are weak, and the government-run enterprises are put to the cart before the horse and there is a situation of misplaced functions. As a result, the income of a large number of workers is lower than the per capita level of urban residents in the country.

2.3. The relationship between the digital economy and the transformation and upgrading of the industrial structure

Most scholars have shown that the digital economy has a positive role in promoting the transformation of industrial structure [6]. Hans-Dieter Zimmermann (1999) focused on the impact of the digital economy on the financial industry and concluded that the digital economy plays an important role in the adjustment of industrial structure. Stiroh (2001) found through research that ICT technology has a pulling effect on related industries in the United States. O'Mahony and Vecchi (2005) analyzed dynamic panel data in the United States and the United Kingdom and found a positive correlation between ICT and industry output growth. Chen Xiaodong and Yang Xiaoxia (2021) empirically tested the incremental expansion of digital industrialization to promote the upgrading of China's industrial structure through the gray correlation entropy model [4]. Fan Xiaoli and Li Qiufang (2021) believe that the digital

economy has obvious spatial spillover effects on the transformation and upgrading of industrial structure, which is an important link in achieving high-quality economic development in China [6]. Dai Lina and Yuan Shijie (2022) believe that the development of the digital economy has a differentiated impact on the heightening of the industrial structure at different quantiles [7]. Wang Yu (2021) based on the spatial econometric model to conclude that the development speed of the digital economy is related to the speed of regional economic development. There are significant differences in the development of the digital economy in the central and eastern regions, the central and western regions, and the eastern region [8].

In summary, more scholars at home and abroad have studied the relationship between the digital economy and the upgrading of industrial structure from the perspective of national panel data, and have conducted a large number of empirical studies. Or the research focus will be biased towards the perspective of regional division of the central and eastern regions, the western region, and the northeast. There are few studies on the impact of the digital economy on the upgrading of industrial structure in special types of regions. Taking the industrial structure level of resource-declining cities as the research object, this paper uses the empirical method of gray correlation to empirically test the impact of digital economy on the transformation and upgrading of the industrial structure of resource-declining cities from three aspects: digital infrastructure, digital industrialization and industrial digitalization, which can make the conclusions more regionally targeted and provide theoretical reference for formulating differentiated and more accurate policies[4].

3. RESEARCH DESIGN

3.1. Selection of Variables and Description of Data Sources

In view of the industrial situation of resource-declining cities, this paper draws on the research results of Liu Min, Liao Jingping, and Peng Qinyu (2021), taking digital infrastructure, digital industrialization, and industrial digitalization as the core explanatory variables, taking the industrial structure level as the explanatory variables, and introducing the level of economic development, government intervention, and foreign trade as the control variables[9].

3.1.1. Explanatory variables

Digital Infrastructure Level (Internet): The Internet is the core industry in the digital economy industry, and its penetration rate can reflect the level of digital infrastructure in a region. This paper draws on the research results and evaluation system of Zhang Xueling and Jiao Yuexia (2017) [10]and selects 23 resource-depleting provinces from 2012 to 2021 ion (Internet) as a representative indicator of digital infrastructure.

Industrial Digitalization Level (ECP): E-commerce is an emerging digital economy business model that integrates traditional industries and the digital economy, which can reflect the level of industrial digitalization in a region. Therefore, we selected the proportion of e-commerce sales in the added value of the tertiary industry in each province (ECP) in 2012-2021 in 2012-2021 in 23 resource-depleting provinces as a representative indicator of industrial digitalization.

Digital Industrialization Level (TTS): The information and communication industry is the core industry of the digital industry, and the total amount of telecommunications services is the main indicator reflecting the development level of the information and communication industry. Therefore, we selected the total amount of telecommunications services (TTS) in 2012-2021 in 23 resource-depleting provinces as a representative indicator of digital industrialization.

3.1.2. The explanatory variable

Industrial Structure Optimization and Upgrading Level (UIS): This article refers to Xie Tingting et al. (2017) [11] The measurement method of industrial structure optimization and upgrading, The industrial structure upgrading index is used to indicate the development trend of the industrial structure of resource-depleting provinces. The specific calculation method is:

$$UIS = \sum_{i=1}^{3} y_i \times i$$

y_i is a resource-depleting city (23 provincial panel data) the proportion of tertiary industries in GDP. i are 1, 2 and 3, representing the primary, secondary and tertiary industries. The calculated value of the industrial structure upgrade coefficient is in the range of [1,3], and the closer it is to 3, the higher the degree of industrial structure upgrading of resource-depleting cities (23 provincial panel data).

3.1.3. Control variables

Economic development level (Pgdp): If the economy wants to develop with high quality, it is imperative to optimize and upgrade the industrial structure. Per capita income levels can represent the economic development of a region. Therefore, this paper selects the Pgdp (gross domestic product per capita) of resource-declining cities (23 provincial panel data) from 2012 to 2021 as one of the control variables.

Government intervention level (Govern): The financial investment of local governments can effectively

promote the optimization and upgrading of regional industrial structure. Therefore, this paper selects the proportion of government general budget expenditure in local GDP in resource-depleting cities (23 provincial panel data) from 2012 to 2021 as one of the control variables.

Level of foreign trade (Trade): The total import and export volume of a region is positively correlated with its position in the national industrial chain. In order to expand the volume of imports and exports and improve the market position, the industrial structure of the region will also be optimized and upgraded. Therefore, this paper selects the total import and export volume/regional GDP of resource-depleting cities (23 provincial panel data) from 2012 to 2021 to indicate the level of foreign trade.

The sample data are all from the websites of the National Bureau of Statistics, the Ministry of Industry and Information Technology and the Ministry of Commerce from 2012 to 2021, the China Statistical Yearbook, the China Information Yearbook and the statistical yearbooks of relevant years in various provinces.

3.2. Model Establishment

In order to test the above three hypotheses, the following multivariate linear empirical model is established:

$$UIS_{it} = \partial_0 + \beta_0 \text{internet}_{it} + \beta_1 \ln TTS_{it} + \beta_2 ECP_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (1)$$

In the above formula, the explanatory variable UIS_{it} is the industrial structure upgrading level of province i in year t, internet_{it} is the core explanatory variable digital infrastructure level, $\ln TTS_{it}$ is the digital industrialization level, ECP_{it} is the industrial digitalization level, X_{it} is the control variable, and ε_{it} is random. perturbation term.

3.3. Empirical Analysis

3.3.1. Descriptive statistical analysis

TABLE 1. DESCRIPTIVE STATISTICAL RESULTS FOR VARIABLE INDICATORS

variable	Sample size	mean	standard deviation	min	max
UIS	207	2.350	0.077	2.182	2.522
Internet	207	0.4368	38.030	0.0061	1.81414
ECP	207	0.1853	0.1095	0.0045	0.52757
LnTTS	207	3.22	3.33	1.786	4.177
Pgdp	207	0.0005	0.0002	0.0002	0.00124
Govern	207	0.2465	0.079	0.1181	0.4617
Trade	207	0.1853	0.1891	0.0270	1.08846

The descriptive statistical results of the variables are shown in Table 1. This paper collects a total of samples of resource-depleted cities (23 provincial panel data) from 2012 to 2021. UIS is the industrial structure upgrading index of resource-depleted cities; Internet is the Internet penetration rate (%) in each region; ECP is the ratio of e-commerce sales to the added value of the tertiary industry in resource-depleted cities(23 provincial panel data) (%); lnTTS is the natural logarithm of the total local telecommunication business (100 million yuan) in resource-depleted cities(23 provincial panel data) (due to the change in data TTS and the standard deviation is large, so the data is taken logarithmically). Pgdp is the per capita GDP of resource-depleted cities (100 million yuan); Govern is the proportion of local general budget expenditure to the regional GDP (%); Trade is the ratio of the total import and export of resource-depleted cities(23 provincial panel data) to the regional GDP. The mean, standard deviation, minimum and maximum value of each variable are counted. It can be seen from Table 1 that the standard deviation of each variable is within the acceptable range. In addition, the dimension gap and standard deviation of the data are all within the acceptable range.

3.3.2. Regression Analysis

According to model (1), we establish a panel data model to test the impact of the digital economy on the upgrading of the industrial structure of resource-declining cities. Table 1 presents the benchmark regression results. Next, we use the grey correlation degree to analyze the influence of each explanatory variable on the industrial structure upgrading index of resource-declining cities. Determine UIS as the "reference value" (parent sequence); perform dimensionless processing on the data; use SPSSAU software to calculate the correlation coefficient, and we get Table 2 after calculation.

TABLE 2. CORRELATION COEFFICIENT RESULTS

item	Pgdp	Govern	Trade	Internet	ECP	LnTTS
Number of samples	1.000	1.000	1.000	1.000	1.000	1.000
Average value	0.890	0.900	0.898	0.908	0.898	0.956
Standard deviation	0.996	1.000	0.994	0.333	0.998	0.854
Minimum	0.897	0.902	0.898	0.897	0.897	0.980
Maximum	0.883	0.902	0.930	0.964	0.905	0.920

As you can see from the table above, there are 6 evaluation items (Pgdp, Govern, Trade, Internet, etc.). ECP, LnTTS), and 5 items of data were analyzed in gray correlation degrees, with UIS as the "reference value" (parent sequence), Study 6 evaluation items (Pgdp, Govern, Trade, Internet, ECP, LnTTS and UIS correlation relationship (correlation degree), the resolution coefficient is 0.50, calculate the customs connection value, as shown in Figure 1 as shown.

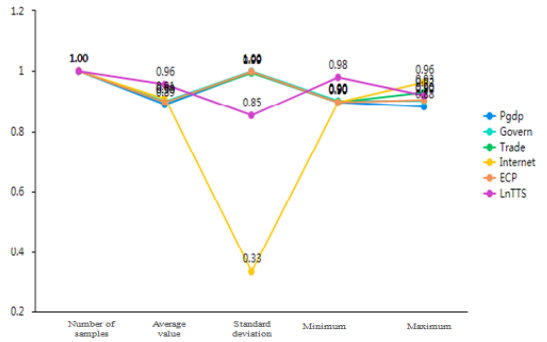

Figure 1. The correlation coefficient to the explanatory variable

Combined with the above correlation coefficient results, weighting processing is performed to obtain the correlation degree value. The calculation results are shown in Figure 2.

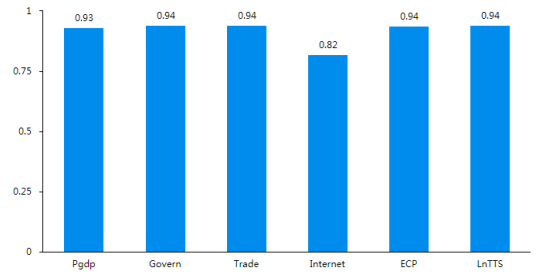

Figure 2. The specific value of the correlation degree of each explanatory variable

The relevance values were used to sort the five evaluation subjects, and the ranking results are shown in Table 3.

TABLE 3. CORRELATION DEGREE RESULTS

Evaluation items	Relevance	ranking
Pgdp	0.933	5
Govern	0.941	3
Trade	0.944	1
Internet	0.821	6
ECP	0.940	4
LnTTS	0.942	2

As can be seen from the above table, for the six evaluation items, the comprehensive evaluation of the level of foreign trade (Trade) is the highest (correlation degree: 0.944).), indicating that the resource decline type city has a good accumulation of import and export trade in the past, and has a strong influence in foreign trade. Using the original advantages and taking advantage of the digital economy, we can well promote the optimization and upgrading of the industrial structure of this special type of city. This is followed by total telecommunications services (LnTTS) (relevance: 0.942). It shows that the digital economy has a good foundation for the development of the information and communication industry in resource-declining cities, which also provides a basic guarantee for the rapid transformation and upgrading of the industrial structure of resource-declining cities. But what we must see is that in resource-decaying cities, internet penetration (i.e., the Internet) is the lowest score for this contributing factor, although total telecom services (LnTTS The development status is good, but compared with other non-resource-declining cities, due to the relatively backward economic development and relatively low income level, the penetration rate of Internet use is significantly low, which is precisely the obstacle factor that seriously affects the use of digital economy in resource-declining cities to upgrade the industrial structure.

4. RESEARCH CONCLUSIONS AND RECOMMENDATIONS

This paper examines the digital economy for resource-depleting cities in 2012-2021 by grey correlation method (select 23 The impact of industrial structure upgrading in the provincial data was measured and analyzed. Through the above empirical test, there are the following main conclusions: the impact of the digital economy on the upgrading of the industrial structure of resource-declining cities is more obvious, and it can promote the optimization and upgrading of the industrial structure of resource-declining cities. Different from the upgrading of industrial structure in other areas with sustainable resource development, in resource-declining cities, in order to better use the digital economy to promote the upgrading of their industrial structure, it is also necessary to increase the depth and breadth of 5G coverage and use 5G The co-construction and sharing of network facilities increases the penetration rate of the Internet. Fight the battle of fiber optic transformation in old residential areas of resource-decaying cities, increase central financial support, and guide local governments and enterprises to increase their enthusiasm for the construction of network infrastructure (such as broadband construction) in resource-decaying cities and remote areas. Promote effective market competition and encourage private capital to enter. The second is to vigorously cultivate Internet technology poverty alleviation talents and build a development model with talents as the core to solve the problem of slow income growth in resource-declining cities. Local governments should also formulate a series of welfare policies at the

grass-roots level under talents to attract e-commerce talents to return and boost the development of e-commerce in resource-depleted cities.

The shortcomings of this paper are due to the difficulty of finding relevant variable data at the city level, or there is no specific statistics, so the provincial data can only be used as the research object, and the next step also needs to be more specific analysis for specific resource-depleting typical cities.

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