Policy Effects of the Establishment of a National-Level Integrated Big Data Pilot Zone on Industrial Structure Upgrading

--Empirical Study Based on City Panel Data

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Abstract. The construction of national-level big data comprehensive pilot zones has profound implications for promoting the development of China's big data industry and accelerating the upgrading of industrial structure to achieve higher quality economic development. However, the current study has not explored in depth the relationship between the establishment of a national big data comprehensive pilot zone and the upgrading of industrial structure. In this paper, based on the panel data of 284 prefecture-level cities in China from 2006 to 2020, we adopt a two-way fixed-effect LSDV model to evaluate the impact of the construction of big data comprehensive pilot zones on the industrial structure upgrading of prefecture-level cities based on the quasi-natural experiment of national-level big data comprehensive pilot zones. The results show that the implementation of the big data comprehensive pilot zone policy can promote industrial structure upgrading, based on which the paper also further analyzes the intrinsic mechanism. In terms of heterogeneity, at the prefecture-level city level, the implementation of the policy has a highly significant positive promotion effect for first-tier cities and fourth-tier cities, a more significant positive promotion effect for second-tier cities, and a non-significant negative inhibitory effect for fifth-tier cities, and this heterogeneity may be related to factors such as the economic base of the cities implementing the policy and the efficiency of the government. The findings of the study provide theoretical support for assessing the policy effects of establishing big data pilot zones to promote the upgrading of China's industrial structure and achieve high-quality economic development in the future. It also provides a literature reference for prefecture-level cities to explore the development of city-level big data industries and to promote the upgrading of existing industries.

Keywords: Big Data · National Comprehensive Experimental Zone for Big Data · Industrial Structure Upgrade · Two-way Fixed Effect Model (key words)

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1 Introduction

1.1 Background

In the face of a new round of global technological revolution and industrial change, data as a key factor of production is widely used in the fields of production, consumption, investment and international trade. Among them, the application of digital technology supported by data in the economic field is particularly prominent, and will certainly contribute to new growth points for economic development in the future. At present, China's digital economy has a certain foundation in terms of development scale and application scenarios, and has a large market advantage and development potential, but China's digital economy is still large but not strong, fast but not excellent and other problems, highlighted in the relatively slow development of traditional industries digitalization, digital industry innovation is insufficient [1]. In order to make up for the shortcomings, accelerate the deployment of big data, deepen the application of big data, and create new advantages in the digital economy, the State Council issued the Outline of Action for Promoting the Development of Big Data (hereinafter referred to as "the Outline") in August 2015. The Outline points out the direction for promoting the opening of digital resources and facilitating the development of digital industries from the top-level planning, policy guidelines and implementation directions, and clearly proposes to carry out regional pilot projects [2]. In September of the same year, Guizhou province launched the construction of the first pilot integrated big data pilot zone; the following year, seven more regions were approved to build national integrated big data pilot zones. At the same time, it is clearly stated in the Outline that we should promote the integration and development of big data with cloud computing, Internet of Things, mobile Internet and other new generation information technologies, explore new business models and new modes of synergistic development of big data and traditional industries, and promote the transformation and upgrading of traditional industries and the development of new industries. By promoting the upgrading of industrial structure and cultivating new economic growth points.

Why does the Outline focus on promoting industrial structure upgrading with the big data pilot zone policy? Industrial structure upgrading refers to the process or trend of transformation of industrial structure from low-level to high-level forms. In the past, relying on the advantages of demographic dividend and low cost of raw materials, China's manufacturing industry has developed rapidly. However, as the demographic dividend slowly fades and domestic factor costs continue to rise, the obvious advantages of China's manufacturing industry are gone, and the development mode of high input, high consumption and high emission has also produced great damage and impact on resources and environment. On the other hand, the advanced industrial structure can also promote a higher level and higher quality development of the economy in the future, fundamentally speaking, the process of continuous economic development is the process of gradual optimization and upgrading of the industrial structure.

1.2 Literature Review

Regarding the impact of government policies on industrial structure, Jiang Yan et al. (2022) empirically analyzed that there is a non-linear relationship between economic policy uncertainty and industrial structure upgrading, reflecting the influence of government actions on industrial structure upgrading [3]. In addition, some other scholars have analyzed specific policies; Xu Yueqian et al. (2021) studied the pilot policy of combining science and technology with finance implemented by five departments, including the Ministry of Science and Technology, and concluded that the pilot policy of combining science and technology with finance can effectively promote the rationalization of industrial structure, reflecting the positive impact of active government policies on industrial structure [4]. Zhang Li (2022) studied the impact of tax structure policies on industrial structure optimization through empirical analysis, and the results showed that China's VAT reform, income tax reform, and the implementation of structural tax reduction policies led to a decrease in the industrial structure deviation index and an increasing rationalization of industrial structure [5].

As for the policy effects regarding the policy of establishing a national-level comprehensive pilot zone for big data, some studies have been conducted by scholars, and Qiu Zixun and Zhou Yahong (2021) found that the establishment of a big data pilot zone can significantly improve regional total factor productivity, and this promotion is led by pure technological progress [6]. Xu, Lin et al. (2022) found that national-level big data comprehensive pilot zone policy has a significant contribution to the improvement of urban innovation capacity [7]. Guo Bingnan et al. (2022) found that the establishment of big data pilot zones can improve the quality of urban economic growth and works mainly through the channels of stimulating entrepreneurial dynamics, promoting human capital accumulation, and promoting green technology innovation [8].

From the current research, it seems that the impact of policies on industrial structure is analyzed either from a macroscopic perspective or from microscopic specific policies, which involves a wide range of specific policies; regarding the policy impact of the national-level big data comprehensive pilot zone, scholars have specifically analyzed its impact on regional total factor productivity and its impact on increasing the innovation capacity of cities, etc. However, no scholars have conducted a more in-depth empirical study on the relationship between the policy of establishing a comprehensive pilot zone for big data and industrial structure. This paper is the first to explore the impact of the policy on industrial structure upgrading based on panel data of prefecture-level cities, and to explore the differences in the effect of the policy on different levels of cities using group regression. This provides theoretical support for evaluating the policy effects of establishing big data experimental zones to promote the upgrading of China's industrial structure and achieve high-quality economic development in the future. It also provides a literature reference for prefecture-level cities to explore the development of city-level big data industries as well as to promote the upgrading of existing industries.

2 Materials and Methods

Based on logical reasoning, we make a preliminary deduction: the establishment of the national big data comprehensive pilot zone gives policy dividends and top-level guidance, and the relevant local governments have issued a series of policy documents to promote the development of big data industry, giving tax concessions and policy subsidies to enterprises in the zone, while improving digital infrastructure and providing high-quality supporting services, which will certainly attract a large number of digital enterprises to invest and build factories here and increase the proportion of tertiary industry. The establishment of big data industrial park makes the effect of industrial clusters appear, and the enterprises develop and share with each other, which breaks the industrial barriers of data elements circulation, promotes the flow of data elements resources, and optimizes the allocation of data resources, and data, as a high-quality production factor, will certainly drive the related industries to develop in a better and better direction, which promotes the upgrading of related industrial structures; on the other hand, the development of digital industry will drive the progress of digital technology, which will increase the proportion of tertiary industry. The development of digital industry will drive the progress of digital technology, and the emergence of new technology will further promote the development of traditional industry in terms of business model, enterprise management structure, resource allocation efficiency, etc. The integration of digital technology and traditional industry will also promote the upgrading of industrial structure.

The above derivation leads to a hypothesis to be verified: the establishment of a national comprehensive pilot area of big data will promote the upgrading of industrial structure.

Logically, the implementation of a good policy will bring positive impact to the implementation area, but its effect is not necessarily the same. CBNData divides prefecture-level cities into different grades based on factors such as concentration of business resources and city hubs. For prefecture-level cities of different grades, higher city grades mean advantages such as better infrastructure, faster and more convenient transportation and communication speed, and more abundant business resources. With the guidance of top-level policies, its response speed and effect should be more rapid and significant. But at the same time, the economic volume and complexity of high-ranking prefecture-level cities are higher than those of low-ranking prefecture-level cities, and the disease of big cities is more prominent, which makes the implementation of top-level policies more difficult. In summary, it is difficult to derive the effect of city rank on industrial structure upgrading, and a deeper investigation is needed at a later stage.

A preliminary hypothesis to be verified is that the effect of the establishment of the national big data comprehensive pilot zone to promote industrial structure upgrading may be related to the city level.

2.1 Model Settings

In this paper, based on relevant panel data of 284 prefecture-level cities in China from 2006 to 2020, Two-way fixed effects LSDV model was selected for regression using Stata/MP 17.0 software, and the model set is as following formula (1).

$$\mathrm{Y}_{up} = \beta_0 + \beta_1 Policy + \beta_2 Control + \alpha_i + \lambda_t + \varepsilon_{it} \tag{1}$$

where Y_{up} denotes the industrial structure upgrading level variable, Policy denotes the big data pilot area policy implementation effect, Control is the control variable, and α_i is the individual effect, λ_t is the time effect, and $\varepsilon_{\mathrm{it}}$ is the error correction term.

2.2 Variable Interpretation

The explanatory variable is the level of industrial structure upgrading. This paper draws on the study used by Fu, Linghui (2010) to measure the level of industrial structure upgrading in each province and obtains the following formula (2) [9].

$$\text{Upgrading} = \sum_{i=1}^{3} q_i \times i \tag{2}$$

where q_i denotes the output value of industry i as a percentage of total output value and is a relative quantity, excluding the effects of time and regional differences. Upgrading is a positive indicator, and the larger its value, the higher the level of industrial structure upgrading.

Policy is the core explanatory variable, which is a dummy variable responding to the implementation of policy or not. If the policy of establishing a national-level integrated big data pilot zone is implemented in that prefecture-level city at that time, the policy of that prefecture-level city is recorded as 1 in that year, otherwise it is 0.

The control variables were selected with reference to other scholars' literature, and several variables with relatively high frequency of use were obtained through data crawlers, including.

Urbanization level (URBR), the rise of urbanization level makes the social infrastructure and social basic system construction more perfect, which can effectively improve the quantity and quality of various production factors, promote the flow and transfer of factor resources, realize the optimal allocation of resources, and thus realize industrial upgrading. In this paper, we use the ratio of urban resident population to the city's resident population to express.

The total number of patents granted (patent), i.e. the total number of patents applied for and granted by the state in the region, reflects the regional innovation capacity of a region and is an important indicator of regional innovation output. Innovation capacity is an important booster of regional industrial structure upgrading. In this paper, the total number of patents granted is used to measure the regional innovation level of the prefecture-level city.

Gross national product per capita (P_GDP), more objectively reflects the level and development of regional economic and social development. A good regional economic level can provide strong financial support for industries in the region and promote industrial structure upgrading. The unit of per capita GNP used in this paper is Yuan.

The amount of actual foreign investment used in the current year (FDI), the advanced management concepts and business operation experience brought by foreign investors can make progress in business operation, and the capital technology brought by foreign investment can also promote the expansion of enterprises and industrial transformation and upgrading. However, at the same time, foreign investment also intensifies the use and waste of resources, which brings negative impact to industrial upgrading. In this paper, the amount of actual foreign investment used in the current year is taken as an indicator to measure the level of foreign investment, in USD million.

The city level (level) is used to evaluate Chinese cities at the prefecture level and above according to five dimensional indices: concentration of business resources, urban hubs, urban people activeness, lifestyle diversity and future plasticity. The cities are divided into first-tier cities, new first-tier cities, second-tier cities, third-tier cities, fourth-tier cities, and fifth-tier cities, and assigned values of 1, 1.5, 2, 3, 4, and 5, respectively, as the basis for subsequent group regression.

The prefecture-level city-level data used in this paper for the empirical study are mainly from the China City Statistical Yearbook, as well as the statistical yearbooks of each prefecture-level city. The city-level classification data are obtained from the CBNData.

2.3 Variable Testing

Basic descriptive statistics were performed on the variable data and the results are shown in the following table (Table 1).

Since the initial model involves multiple independent variables, the problem of multicollinearity may occur, for this reason, the cointegration between the independent variables is tested, and here the Variance inflation factor (VIF) is used to test the cointegration problem, and the results are shown in the following table (Table 2).

The VIF values among the independent variables were tested to be less than 10, and the covariance among the independent variables was weak, and the covariance test was passed.

Table 1. Descriptive Statistics

Variable	N	Mean	p50	SD	Max
upgrading	4260	247.4	260.5	71.36	367.4
policy	4260	0.0820	0	0.275	1
URBR	4260	52.10	50.04	16.20	110.1
patent	4260	4453	823	12293	221899
P GDP	4260	42733	34254	32872	467749
FDI	4260	72908	15153	185952	3.083e + 06

Table 2. Collinearity Test

Variable	VIF	1/VIF
P_GDP	2.100	0.477
URBR	1.870	0.536
patent	1.850	0.541
FDI	1.530	0.655
policy	1.060	0.946
Mean	VIF	1.680

3 Results and Discussion

3.1 The Results of LSDV

The original base model belongs to the mixed OLS model, and in the process of optimizing the model for testing, after testing for individual effects and time effects, the results showed that both the fixed-effects model and the random-effects model outperformed the mixed OLS model. For this reason, the hausman test was performed and the result was p-value = 0.0000, so the fixed-effects model was chosen. Due to the use of policy as a policy dummy variable, this paper uses the LSDV approach and controls for individual and time effects.

The mixed OLS regression results, random effects model results, fixed effects model results, and LSDV model results controlling for individual effects and time effects are presented in Table 3 from left to right. Through comparison and analysis, the LSDV model regression results were selected as the final results.

The regression results show that the policy of establishing a national-level comprehensive pilot zone for big data has a significant positive influence effect on industrial structure upgrading, which is consistent with the research hypothesis. The construction

Table 3. Empirical Results

	OLS	Re	Fe	Fe10
	upgrading	upgrading	upgrading	upgrading
policy	-30.683^{***}	-30.683^{***}	-27.242^{***}	4.161^{***}
	(3.985)	(3.985)	(4.925)	(1.108)
URBR	−0.050	−0.050	-1.775^{***}	0.186^{***}
	(0.090)	(0.090)	(0.205)	(0.064)
patent	0.000^{***}	0.000^{***}	-0.000^{**}	-0.000^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
P_GDP	0.000^{***}	0.000^{***}	0.001^{***}	0.000^{**}
	(0.000)	(0.000)	(0.000)	(0.000)
FDI	−0.000	−0.000	-0.000^{***}	-0.000^{**}
	(0.000)	(0.000)	(0.000)	(0.000)
_cons	233.718^{***}	233.718^{***}	308.284^{***}	245.587^{***}
	(3.911)	(3.911)	(9.580)	(2.923)
N	4260.000	4260.000	4260.000	4260.000
r2_a	0.050		−0.004	0.955
Hausman Test		Prob > chi2 = 0.0000		
code				Yes
year				Yes

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of national big data comprehensive pilot zones promotes data resource management and sharing and opening, facilitates the circulation of data elements driving the development of big data industry gathering, promotes big data system innovation, and promotes the development of related infrastructure. These positive impacts promote the development of new industries related to big data on the one hand, and the integration and development of data elements, digital technology and traditional industries on the other hand, so as to realize the upgrading of industrial structure. The specific mechanism of action needs to be studied in greater depth.

3.2 Analysis of Heterogeneity

In order to further investigate the impact of establishing a national big data comprehensive test area on prefecture-level cities at different city levels, a group regression model was established. Based on the level of prefecture-level cities, 284 prefecture-level cities were divided into six groups, and the LSDV model controlling for individual effects and time effects was used to conduct regression analysis for each of the six groups, and the specific results were obtained as shown in the following table (Table 4).

According to Table 4, it is obvious that the establishment of national-level big data comprehensive trial zone (policy) has a significant difference in the effect on the prefecture-level cities of different urban classes. Specifically, it has an extremely significant positive policy effect for first-tier and second-tier cities. This may be because, firstly, with the establishment of big data pilot zones, the new generation of information and communication technology has been popularized and applied, which has alleviated

Table 4. Grouped Regression Results

	Fe10	Level = 1	Level = 1.5	Level = 2	Level = 3	Level = 4	Level = 5
	upgrading	upgrading	upgrading	upgrading	upgrading	upgrading	upgrading
policy	4.161***	56.332***	0.024	6.432**	0.816	13.446***	−0.120
	(1.108)	(8.560)	(2.182)	(3.225)	(1.660)	(2.787)	(1.641)
URBR	0.186***	−2.357***	0.240	0.574**	0.112	0.139	0.045
	(0.064)	(0.674)	(0.234)	(0.236)	(0.134)	(0.147)	(0.063)
patent	−0.000***	−0.000***	0.000*	−0.000	−0.000	−0.002**	−0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
P_GDP	0.000**	0.000	0.000*	−0.000*	0.000***	0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FDI	−0.000**	−0.000***	0.000	−0.000	0.000***	−0.000	−0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	245.587***	526.605***	265.138***	242.868***	245.639***	241.471***	247.048***
	(2.923)	(60.351)	(15.604)	(13.776)	(5.674)	(6.193)	(2.673)
N	4260.000	60.000	225.000	450.000	1035.000	1260.000	1230.000
r2_a	0.955	0.997	0.992	0.965	0.970	0.916	0.983

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

the congestion effect in the process of economic development in high-ranking cities and further brought into play their advantages of resource allocation. Secondly, high-ranking cities themselves have better economic foundation and social governance system, which can give full play to the policy dividend advantage of top-level policy guidance [8]. Finally, the government of first-tier cities works more efficiently. On the one hand, a highly efficient government can quickly promote the implementation of relevant policies and bring into play the policy dividend effect more quickly; On the other hand, an efficient government has a strong ability to mobilize the region's resource endowment and innovation, and is able to designate various countermeasures to solve the difficulties in policy implementation in a more localized manner and enhance the effectiveness of policy implementation [10]. Through the above advantages, high-ranking cities are better able to give full play to the policy's promotional effect on industrial structure upgrading.

The effect of the implementation of the policy on the fourth-tier cities also shows a significant positive effect. In this regard, Qiu Zixun et al. pointed out that the productivity boosting effect of the pilot zone is more significant in areas with less developed economies, low innovation levels, and serious net labor turnover [6]. This may be because, among the fourth-tier cities, the low level of innovation and severe labor force loss have become one of the key factors limiting their development, and the policy of establishing a comprehensive pilot zone for big data can effectively compensate for the low level of innovation and severe labor force shortage. By establishing the pilot zone to break the barriers to the free flow of data elements, it can attract a large number of advanced technology enterprises to settle in the city and effectively promote the development of its innovation capacity. At the same time, through the development of digital technology, the traditional manpower is replaced by machines to make up for the shortage of labor force. In this way, the policy will have a positive effect on industrial structure upgrading.

In addition, the policy effect shows an insignificant negative effect in the fifth-tier cities, which may be related to the poor economic base, poor transportation and communication, and inefficient policy implementation in the fifth-tier cities. Inefficient policy implementation not only wastes human and material resources and financial resources, but also fails to give full play to the advantageous effects that the policy has, which may affect the momentum of industrial structure upgrading.

4 Conclusions

Using panel data of 284 prefecture-level cities from 2006 to 2020, this paper empirically analyzes the impact of the policy of establishing a pilot zone on industrial structure upgrading based on a national-level comprehensive pilot zone for big data, using the LSDV model and group regression model, and mainly obtains the following conclusions.

First, the establishment of the national big data comprehensive pilot zone has a significant positive effect on industrial structure upgrading; second, the implementation of this policy has a heterogeneous effect on the prefecture-level cities in different urban classes. Specifically, it has a highly significant positive promotion effect for first-tier cities and fourth-tier cities. For second-tier cities, it has a relatively significant positive promotion effect. In addition, there is a non-significant negative inhibitory effect for fifth-tier cities.

To sum up, this paper puts forward the following policy recommendations: First, the country should take the implementation of the construction of comprehensive pilot zones of big data in some regions as a pioneer, and continue to steadily promote the construction of national-level comprehensive pilot zones of big data. And based on this, summarize the construction experience of the pilot zone, give full play to the leading demonstration role of the pilot zone, and lay the foundation for the implementation of big data development strategy and promotion of industrial structure upgrading in a larger region, and even nationwide. Second, the construction of big data comprehensive pilot zone has a significant impact on industrial structure upgrading, which shows a way for cities and even the country to promote industrial structure upgrading, that is, it can make full use of and play the role of data production factors to promote industrial structure upgrading. Thirdly, the establishment of national big data comprehensive pilot zones should be tailored to local conditions, and the construction should be carried out realistically according to the specific conditions of prefecture-level cities in different city levels. When promoting the policy, we should focus on the economic base of the city, the efficiency of the local government and other factors, to really ensure that the policy can be implemented reasonably and steadily. Specifically, first-tier cities and second-tier cities should continue to rely on policy advantages, continue to promote the development of big data industry, and promote the industrial structure to a higher level. When other cities encounter difficulties in the process of implementing the policy, they can take the implementation experience of first-tier and second-tier cities as reference, summarize the problems and move on. Meanwhile, fourth-tier and fifth-tier cities should also seize the policy opportunities in order to promote the development of big data-related industries and the upgrading of industrial structure.

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