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Study on the Impact of Industrial Structure Change on Total Factor Productivity in Henan Province

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Abstract: *The impact of industrial structure change on total factor productivity is explored by using a fixed-effects model, which measures the spatial variation of industrial structure change in Henan Province from 2001 to 2020, combined with the Theil index. The study finds that the spatial differences in industrial structure change in Henan Province are more obvious, and the spatial differences in industrial structure rationalisation increase more than industrial structure advancement; by testing the province's sub-regions, it is found that industrial structure rationalisation and industrial structure advancement in the Central Plains City Cluster show a positive effect on total factor productivity; the economic zones in North Henan Province and West and Southwest Henan Province show a positive effect on total factor productivity in The rationalization of the industrial structure in the North Henan Economic Zone, West Henan and Southwest Henan Economic Zone has a positive effect on total factor productivity. The examination by periods shows that the impact of industrial structure rationalisation on total factor productivity is stronger than that of industrial structure upgrading and becomes the main influencing factor for total factor productivity improvement.*

Keywords: *Total factor productivity; Advanced industrial structure; Rationalization of industrial structure; Industry Structure*

1. Introduction

The process of economic development is a continuous process of industrial restructuring[1]. Specifically, in the process of economic development, rapid economic development can promote the change of industrial structure. Specifically, in the process of economic development, the rapid development of the economy can promote the change of industrial structure, and in turn, the change of industrial structure can also promote the high-quality development of the economy. Since the reform and opening up of China, China has always insisted on "economic construction" as the centre, making economic development the core work to maintain the country's livelihood. For a long time, China has achieved excellent results in the process of economic development by adopting a "crude, high energy consumption and high input" approach to development[2]. In the new era, the Party, at the 19th National Congress of the People's Republic of China, has made a significant contribution to the development of the country. In the new era, the Party has clearly pointed out in the 19th National Congress Report that China's economy has shifted from high speed growth to a stage of high quality growth and is in the midst of a critical period of transforming the development mode, optimising the economic structure and changing the growth momentum[3]. In this context, China's economy has been transformed from a high growth rate to a high quality growth stage. Against this background, governments at all levels in China are committed to optimising the industrial structure and modernising the industrial chain. Henan Province, as one of the important inland provinces in China, has gradually changed from a large agricultural province to a large industrial province with the rapid development of China's economy, and is in a critical period of transforming its economic development mode and promoting the transformation and upgrading of its industrial structure. However, while the industrial structure of Henan Province is changing rapidly, spatial differences in economic development and industrial structure change exist and tend to continue to expand. In 2020, for example, Zhengzhou City ranks first in the province in terms of GDP per capita, at 96,000 yuan, which is 2.67 and 2.6 times higher than the next two cities, Zhoukou and Shangqiu respectively. In addition, the change of industrial structure in Henan Province is also characterised by spatial imbalances. In general, the pace of change of industrial structure in the western part of Henan Province is slow, especially in terms of industrial structure and scale, while the process of change of industrial structure in the Central Plains urban agglomeration is faster and is ahead of other regions in terms of both the level of industrial structure rationalisation and the level of industrial structure

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sophistication.

Although industrial structural change and total factor productivity have been a common topic of concern in academic circles at home and abroad, there are relatively few studies on the impact of industrial structural change on total factor productivity, and there is no consensus on the conclusions of related studies. In the existing literature, studies on the impact of industrial structural change on total factor productivity have mainly focused on the following aspects: First, industrial structural change can increase total factor productivity; Thabet Khaled[4] The results show that industrial structure has a positive impact on total factor productivity; Liu Jing argues that changes in industrial structure have a certain contribution to total factor productivity, and that the structural dividend still exists in China, but the impact is gradually declining[5]; Liu Xuan[6] The study concluded that the change of industrial structure in the context of the Internet can promote the increase of total factor productivity. The second is the "negative structural dividend" hypothesis, which means that industrial structural change has a negative effect on total factor productivity. Qian Chunhui[7] The hypothesis is that in the process of industrial structure evolution, the increase in total factor productivity mainly comes from the flow of labour factors within the secondary industry, while the transfer of capital between industries has a "negative structural benefit"; Yang Xiangyang[8] Using data from 230 prefecture-level cities in China from 2004 to 2016 as a sample, the study combined with a fixed-effects model to measure that the evolution of the industrial structure in the direction of service does not bring about total factor productivity growth; Xu Jiajun[9] Using the Yangtze River Delta "three provinces and one city" as the research object, the PVAR model was used to analyse that the upgrading of industrial structure in low- and middle-income areas in the Yangtze River Delta region would hinder the growth of total factor productivity; Fagerberg investigates the impact of manufacturing changes on total factor productivity in 39 countries from 1973 to 1990, and verifies the existence of "negative structural benefits"[10].

Although there are in-depth analyses and explanations of the relationship between industrial structural change and total factor productivity, most of the literature usually starts from a certain type of industry or sector and only analyses its impact on total factor productivity at the time of change, and therefore lacks an analysis of its specific spatial and temporal changes. In addition, most of the literature does not analyse the heterogeneous impact of industrial structural change on total factor productivity by dividing it into two dimensions: industrial rationalisation and industrial upgrading. Therefore, this study takes the industrial structure change as the research perspective, and starts from two dimensions: industrial structure rationalisation and industrial structure upgrading. The study also provides feasible policy recommendations based on the findings and the actual situation in Henan Province, which are of theoretical value and practical significance in promoting the optimisation and upgrading of the industrial structure in Henan Province, achieving coordinated regional economic development and improving the overall economic strength of Henan Province.

2. Spatial differences in industrial structural change

2.1. Measurement of industrial structural change

The change of industrial structure refers to a trend of the industrial structure itself changing from unreasonable and imperfect to reasonable and benign or the inherent trend of the industrial structure changing from low level to high level. The change of industrial structure has two main aspects, one is the rationalization of industrial structure, which is expressed as a proportional relationship between input and output in the process of industrial development, generally the process of rationalizing industrial structure by measuring labour as input and output value as output; the second is the advanced industrial structure, which generally refers to the process of transforming industrial structure from primary industry to secondary industry and tertiary industry, and the process of transforming industrial structure from low level and low value-added industries to high level and high value-added industries[11] .

2.1.1. Rationalisation of industrial structure

There are currently two main approaches to measuring industrial rationalisation: one is to use the structural deviation method, which mainly indicates the degree of difference between the share of employment in a certain industry and the share of value added in the industry. Many scholars in China have adopted this method to measure industrial rationalization, such as Guan Xueling[12] , Fu Yuanhai[13] The method can be used to a large extent to measure industrial rationalisation. Although this method can measure the efficiency of optimal allocation of resources to a large extent, it mainly reflects the coupling relationship between the output structure of a certain industry and the employment structure. As the

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economy has a strong unbalanced nature, this method uses absolute indicators and does not differentiate the weights of the three major industries, so the importance of different industries will be ignored[14].The second method is used in this study. This study adopts the second method, namely the generalised entropy method. Referring to the study of Dry Chunhui[15-16] et al.'s approach to industrial structure rationalisation measurement, the measurement model of industrial structure rationalisation can be defined as

$$H = \sum_{n=1}^{n} \left(\frac{Y_{it}}{Y_t} \right) \ln \left(\frac{Y_{it} / L_{it}}{Y_t / L_t} \right) \tag{1}$$

$$K = 1 - H = 1 - \sum_{n=1}^{n} \left(\frac{Y_{it}}{Y_t} \right) \ln \left(\frac{Y_{it} / L_{it}}{Y_t / L_t} \right) \tag{2}$$

2.1.2 Advanced industrial structure

There are also two main research approaches to the study of industrial structure advancement. Most scholars in the past have used the product of the output share of each industrial sector and labour productivity as a measure of industrial structure height, such as Liu Wei[17] The product of the output share of each industrial sector and labour productivity is used as a measure of the height of industrial structure. This study adopts the second method, taking the output value of each industry as the main object of measurement, and using the size of its ratio to reflect the advanced industrial structure. Wu Wanzong[18] According to Clark's law, the advanced industrial structure can be measured by the proportion of value added of the secondary and tertiary industries. This study draws on He Weida's[19] In this study, the advanced industrial structure is measured by the ratio of tertiary industry to non-tertiary industry, based on the measurement model of He Weida et al. Therefore, the indicators of the advanced industrial structure can be set as follows

$$TS = \frac{Y_3}{Y_1 + Y_2} \tag{3}$$

In equation (3), Y_1 , Y_2 ,and Y_3 denote the GDP of primary, secondary and tertiary industries in a region. TS The higher the value of TS , the more advanced the industrial structure is, and vice versa, the less advanced the industrial structure is.

According to equations (2) and (3), this study measures the level of industrial structure rationalisation and industrial structure advanced in 18 provincial cities in Henan Province from 2001 to 2020. Taking 2001 and 2020 as examples (see Figure 1), the degree of industrial structure rationalisation in all cities shows an upward trend. Compared with 2001, the industrial structure rationalisation level of all cities in 2020 has improved significantly, with Puyang City having the largest increase in industrial structure rationalisation level, with its industrial structure rationalisation index in 2020 increasing by 0.468 compared with 2001.

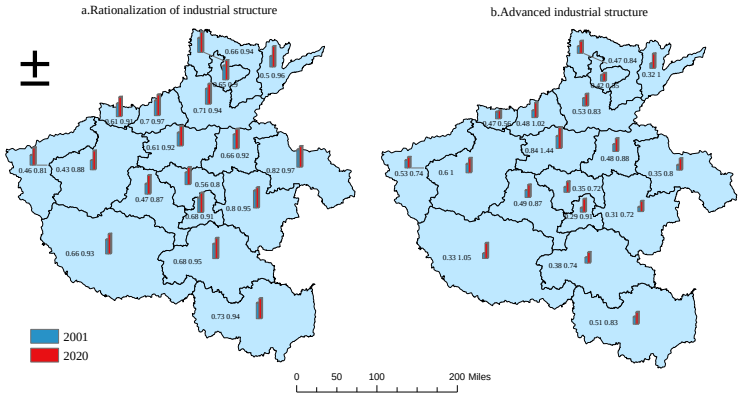

Figure 1: Difference index of industrial structure change in Henan Province in 2001 and 2020

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The rate of improvement is more obvious, all above 0.5 (see Figure 1), but the increase in the advanced level of industrial structure in Hebi ,Sanmenxia and Jiyuan is smaller, with the smallest increase in the advanced level of industrial structure in Jiyuan, where the advanced level in 2020 is only 0.087 compared to 2001.

2.2 Theil Index

In order to further investigate the spatial variation of industrial structure change in Henan Province, this study uses the Theil index to measure the degree of spatial variation of industrial structure change in Henan Province. The larger the value of the Theil index, the greater the spatial variation, and vice versa, the smaller the spatial variation. The Theil index formula constructed in this study is based on Theil[20] Theil's previous research. The Theil index of industrial structural change can be expressed as

$$T = \frac{1}{n}\sum_{i=1}^{n} \frac{y_i}{\overline{y}} \log\left(\frac{y_i}{\overline{y}}\right) \tag{4}$$

In equation (4), y represents the level of industrial structure rationalisation and sophistication of each city in Henan Province, and n represents the total number of regions in the study sample.

2.2.1 Overall gap in the rationalisation of industrial structure

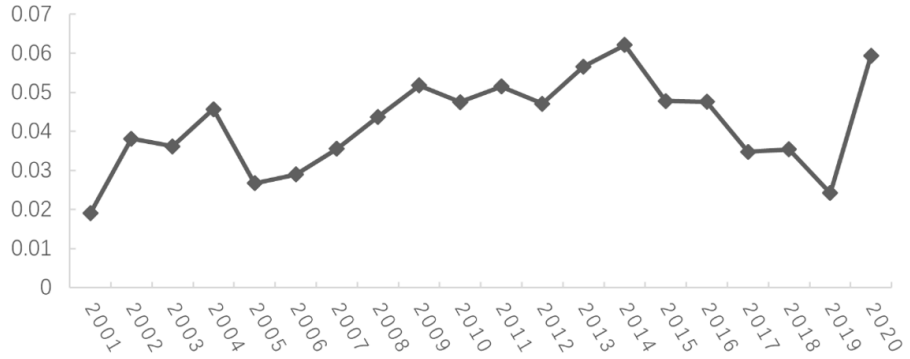

Figure 2: Overall spatial variation index of industrial structure rationalization in Henan Province, 2001-2020

Figure 2 shows the general trend of the evolution of the overall spatial differences in the rationalisation of industrial structure in Henan Province. It can be seen that the Theil index of industrial structure rationalisation as a whole shows a fluctuating upward trend, with the Theil index of industrial structure rationalisation in 2001 and 2020 being 0.019 and 0.059 respectively, and the calculation shows that the Theil index of industrial structure rationalisation in 2020 is 3.1 times of that in 2001. Among them, the Theil index of industrial structure rationalization in Henan Province from 2005 to 2014 is fluctuating and rising, with an annual growth rate of 13.2%, and the spatial gap of industrial structure rationalization from 2014 to 2019 shows an overall trend of narrowing, from 0.062 in 2014 to 0.024 in 2019 , with an annual decline rate of 15%, which to a certain extent indicates that the expansion of the spatial difference in industrial structure rationalization has slowed down, and the industrial structure rationalization among regions is generally more balanced. However, the spatial difference of industrial structure rationalization in 2019-2020 shows a substantial expansion, and the Theil index of industrial structure rationalization in Henan Province is 0.059 by the end of 2020, an increase of 0.035 from 2019.

2.2.2 Overall gap in advanced industrial structure

In addition to the overall gap in the rationalisation of industrial structure in Henan Province, this study also measures the overall gap in the advanced industrial structure. As shown in Figure 3, the spatial gap in the advanced industrial structure of Henan Province is generally balanced during the period 2001-2020, with the Theil index mainly concentrated in the range of 0.01 to 0.02. Among them, the spatial difference of industrial structure advanced showed a decreasing trend from 2001 to 2003, and the Theil index of industrial structure advanced rose from 0.007 to 0.022 from 2003 to 2010, with an average annual increase of 0.002, indicating that the spatial difference of industrial structure advanced is gradually expanding. There is a small decline period from 2013 to 2020, with an average decline rate of 5.6% in the regional gap of advanced industrial structure.

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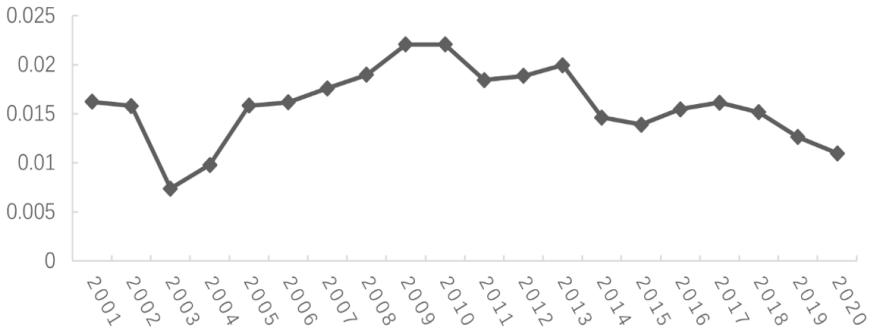

Figure 3: Overall spatial variation index of industrial structure advanced in Henan Province, 2001-2020

3. The impact of industrial structural change on total factor productivity

3.1 Description of data

This study selects panel data from Henan Province from 2001 to 2020 to analyse the effect of industrial structure change on total factor productivity in Henan Province. The selected data are obtained from the Henan Provincial Statistical Yearbook. Total factor productivity is set as the explanatory variable, while the core explanatory variable is industrial structure change, which consists of two main measures, namely industrial structure rationalisation and industrial structure upgrading. At the same time, a number of control variables are included in the model to take into account other influencing factors that may have an impact on total factor productivity. In order to avoid the influence of excessive abnormal fluctuations, this study refers to Feng Zhen[21] In order to avoid excessive abnormal fluctuations, this study refers to the definition of control variables by Feng Zhen et al. and adopts the non-parametric Malmquist index combined with DEAP2.1 software to measure total factor productivity, with the size of the economy expressed as the logarithm of GDP, the size of the government measured as the share of government expenditure in GDP, the degree of openness measured as the share of total local imports and exports in GDP, and the level of education expressed as the logarithm of education expenditure per capita. The level of education is expressed as the logarithm of education expenditure per capita, which reflects the degree of variation in education expenditure between regions.

3.2 Setting of the model

This study aims to analyse the impact of industrial structure change on total factor productivity, so panel data for 18 provincial cities in Henan Province over the period 2001-2020 were selected and combined with a fixed effects model to analyse this issue, which is modelled as follows:

$$Y_{it} = \alpha_1 H_{it} + \alpha_2 TS_{it} + \alpha_3 X_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

Table 1: Descriptive statistics of variables (N=360)

Variable type	Variable name	Variable symbols	Minimum value	Maximum value	Average value	Standard deviation
Explained variables	Total Factor Productivity	*tfp*	0.038	2.991	1.471	0.786
Explanatory variables	Rationalisation of industrial structure	*h*	0.027	0.984	0.286	0.183
	Advanced industrial structure	*ts*	0.208	1.441	0.526	0.213
Control variables	Size of the economy	*lngdp*	0.293	8.079	6.655	1.417
	Size of Government	*gov*	0.032	7.478	0.298	1.074
	Degree of openness to the outside world	*open*	0.000	0.113	0.017	0.017
	Education expenditure per capita	*lnedu*	0.786	3.640	2.807	0.476

In model (5), Y denotes total factor productivity, the subscript i denotes provincial cities and t denotes year. The core explanatory variables H denote rationalisation of industrial structure and TS

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denote advanced industrial structure. X denotes a range of control variables including size of economy (*lngdp*), size of government (*gov*), *openness* to the outside world (*open*) and education level (*lnedu*). μ_i denotes individual effects and ε_{it} denotes disturbance terms. Descriptive statistics were conducted for each variable and the results are shown in Table 1.

4. Results of regression analysis of industrial structure change on total factor productivity

4.1 Sub-regional visits

In the previous paper, we focused on the industrial structure change and its spatial variation across provincial cities in Henan Province, focusing on the provincial level, however, the subject of this study is the impact of industrial structure change on total factor productivity in Henan Province. It is necessary to further analyse the specific situation of different regions in order to gain a deeper understanding of the development of the regional economy from the perspective of industrial structure. In this study, the province is divided into four economic zones, namely the Central Plains City Cluster, the North Henan Economic Zone, the West Henan and Southwest Henan Economic Zone and the Yellow and Huai Economic Zone, as shown in Figure 4.

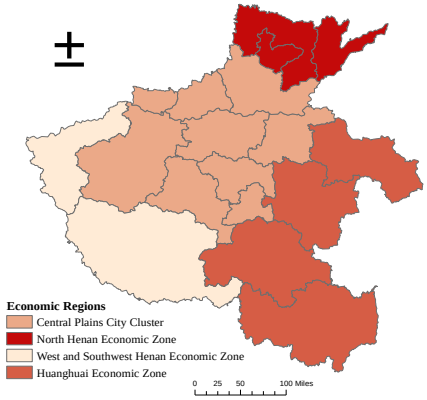

Figure 4: Regional distribution of the economy of Henan Province

It can be seen that the four economic regions belong to different geographical zones, so there are large differences between them in terms of industrial structure, economic volume, urbanisation level and industrialisation. The widening of regional differences will not only affect the implementation of Henan's co-ordinated development strategy but also severely restrict the further strengthening of Henan's economic power. Therefore, it is of great importance to study the impact of industrial structure change on total factor productivity in Henan Province from the perspective of industrial structure change, as shown in Table 2.

Table 2: Sub-regional regression test results

Dependent variable	All samples	Central Plains City Cluster	North Henan Economic Zone	Economic Zone of West and Southwest Henan	Yellow-Huai Economic Zone
h	0.614*	0.872*	1.839*	1.670*	0.109
	(-2.342)	(-2.052)	(-2.162)	(-1.662)	(-0.138)
ts	-0.133	0.576*	-0.574	-1.032	-2.263**
	(-0.665)	(-2.367)	(-0.810)	(-1.201)	(-4.815)
lngdp	-0.086*	0.005	-0.139	-0.138	-0.272**
	(-2.254)	(-0.117)	(-1.240)	(-0.939)	(-3.051)
gov	5.684*	0.084*	5.315	13.013	16.427**
	(-2.141)	(-2.258)	(-0.78)	(-1.710)	(-4.456
open	-0.012	-5.226	-11.754	-6.567	-34.374*
	(-0.344)	(-1.531)	(-1.432)	(-0.856)	(-2.450)
lnedu	-0.087	-0.077	0.257	-0.744	-1.108**
	(-0.799)	(-0.444)	(-0.464)	(-1.695)	(-3.165)
R^2	0.796	0.853	0.602	0.816	0.769
Sample size	360	180	60	40	80

Note.t-values in brackets, * and ** denote 5% and 10% significance levels respectively.

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From a province-wide perspective, the rationalisation of industrial structure has a positive impact on economic development, contributing to an increase in total factor productivity at a significant level of 5%, while the advanced industrial structure does not show a significant impact on economic development. What can be seen is that for every 1% increase in the rationalisation of the industrial structure, the total factor productivity increases by 0.614% in theory. It can be seen that at this stage, the contribution of industrial rationalisation to total factor productivity in Henan Province is higher than that of industrial restructuring. At the same time, government size and openness level show significant effects on total factor productivity, where government size promotes total factor productivity at a significant level of 5% and economic size inhibits total factor productivity at a significant level of 5%. Based on the regression analysis of all samples, this study further divides Henan Province into four economic zones and determines the influence of industrial structure changes on total factor productivity in different zones. Both industrial structure rationalisation and industrial structure upgrading have a significant effect on total factor productivity in the Central Plains urban agglomeration, with the positive effect of industrial structure rationalisation on total factor productivity being higher than that of industrial structure upgrading. The positive effect of industrial restructuring on total factor productivity is higher than that of industrial restructuring, and the intensity of the effect is about 1.51 times higher than that of industrial restructuring (0.872/0.576). This is probably due to the earlier evolution of the industrial structure in the Central Plains urban agglomeration, the higher level of industrialisation and urbanisation, the larger share of financial services output in the total economy, the more developed secondary and tertiary industries, and, in addition, the earlier efficient and intensive development of agriculture. It is worth noting that, among other influencing factors, the degree of openness shows a positive contribution to the development of the economy. For the economic zone in northern Henan, the rationalisation of the industrial structure has a significant contribution to total factor productivity, while the advanced industrial structure does not have a significant impact on the increase of total factor productivity. The possible reason for this situation is that in the development of the economy of North Henan Economic Zone, due to the rich natural resources and strong industrial base in the region, the share of the secondary industry in the regional GDP is higher than that of other industries, resulting in economic growth mainly relying on the pulling effect of the secondary industry. The rationalisation of the industrial structure in the economic zones of west and southwest Henan promotes economic development at a significant level of 5%, and the effect of advanced industrial structure on total factor productivity is not significant. The reason for this phenomenon may be that although the economic zones in West and Southwest Henan have a lower level of development of various industries, the development of industries is generally more reasonable and the primary, secondary and tertiary industries in the region are all developing steadily and in a coordinated manner. In 2020, for example, the economic zones in West and Southwest Henan had a GDP of RMB 537.656 billion, of which the added value of the three industries accounted for 16.23%, 13.01% and 10.96% of the province's total respectively. More different from the other economic zones is the Yellow and Huai Economic Zone, the analysis results show that the advanced industrial structure presents a suppressive effect on total factor productivity at a significant level of 10%, and the rationalisation of industrial structure is not significant. The reasons for this are mainly attributed to the structural problems caused by the natural conditions of the Huang-Huai-Huai Economic Zone, which has long relied on superior soil and water resources for agricultural production activities and has a relatively homogeneous industrial structure, which, together with the serious outflow of labour from the region, has led to slow industrial transformation and upgrading, and a lower level of industrial structure rationalisation and industrial structure sophistication than other economic zones.

4.2 Examination by period

Since the new century, Henan Province has continuously promoted the change of industrial structure, and the industrial structure has shown different evolutionary characteristics in different historical periods. To further examine the role of each influencing factor on total factor productivity at different development stages, this study divides the entire sample into four stages for regression analysis, namely 2001-2005, 2006-2010, 2011-2015 and 2016 -2020.

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Table 3: Regression test results by time period

Dependent variable	2001-2005	2006-2010	2011-2015	2016-2020
h	1.386**	-1.080*	0.502	4.248**
	(3.594)	(-1.996)	(0.268)	(5.142)
ts	-0.765	-1.348	3.050*	-1.661*
	(-1.433)	(-1.918)	(2.356)	(-2.601)
lngdp	0.023	0.572	-5.522	-8.197**
	(0.581)	(1.786)	(-1.857)	(-5.331)
gov	1.264**	-0.085**	-0.533	-6.166
	-4.11	(-2.902)	(-0.061)	(-1.294)
open	1.651	-9.64	-18.910**	3.118
	(0.47)	(-1.666)	(-2.658)	(0.454)
lnedu	-0.723**	2.615**	-6.167**	-0.134
	(-3.712)	(5.888)	(-2.871)	(-0.076)
R^2	0.503	0.506	0.587	0.830
Sample size	90	90	90	90

Note. t-values in brackets, * and ** denote 5% and 10% significance levels respectively.

The results of the test are shown in Table 3. During the period 2001-2005, the impact of industrial structure rationalisation on total factor productivity was stronger than other influencing factors, and it increased total factor productivity at a significant level of 10%, while the effect of industrial structure advanced was not significant. This may be due to the fact that the advanced level of industrial structure in Henan Province during this period was low, and economic growth was mainly driven by the development of agriculture and industry. During the period 2006-2010, with the further liberalisation of China's investment sector, many foreign capitals entered China's inland areas, and although Henan Province attracted a large amount of foreign capitals, these capitals were mainly concentrated in labour-intensive industries and resource-intensive industries. This, coupled with the global economic crisis, has not resulted in a significant increase in total factor productivity. However, it is worth noting that the level of education improved during this period, which to some extent had a positive impact on economic development. In contrast to the period 2001-2005, the advanced industrial structure contributed to the increase in total factor productivity at a significant level of 5% in 2011-2015, while the rationalisation of the industrial structure did not show an impact effect. In this period, after the economic crisis, Henan Province actively promoted the transformation and upgrading of its industrial structure, and used industrial agglomerations as a carrier to strengthen innovation-driven development, actively develop strategic emerging industries, and comprehensively improve the level of informatization of the whole industry, thus the level of industrial structure advanced was further improved. 2016 -2020 The period of industrial structure Rationalisation has a significant role in promoting the improvement of total factor productivity, while the advanced industrial structure has a certain degree of inhibiting effect on total factor productivity. On the one hand, this may be due to the rapid development of the tertiary sector in Henan Province in recent years with the support of policies and the initial optimisation and upgrading of the primary and secondary sectors, which has further improved the degree of rationalisation of the industrial structure and become a major influencing factor of economic growth. The weak industrial base makes it impossible to take over the transfer of high-tech industries from the eastern region to the region, thus hindering to a certain extent the transformation of economic development dynamics and ultimately inhibiting the quality development of the economy.

4.3 Robustness tests

In order to verify the accuracy and reliability of the previous conclusions, it is necessary to conduct robustness tests on the previous conclusions. The previous paper has been using the generalised entropy method and the output weight method to measure the rationalisation and advanced industrial structure. Therefore, in the robustness check, we try to use the structural deviation and employment-to-population ratio methods to measure the rationalisation and upgrading of industrial structure, and the results will be regressed again.

The results of the robustness test are shown in Table 4. The two core explanatory variables of industrial rationalisation and industrial upgrading are measured using other methods and the findings do not differ significantly from those above. Therefore, the findings of the study can be considered to have passed the robustness test.

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Table 4: Test results for changing the explanatory variables measures

Dependent variable	All samples	Central Plains City Cluster	North Henan Economic Zone	Economic Zone of West and Southwest Henan	Yellow-Huai Economic Zone
h	0.034*	1.121**	0.937*	1.292*	-0.864
	(-0.407)	(-4.550)	(-2.208)	(-2.224)	(-2.651)
ts	0.208	-0.096	-1.527	-0.571	-3.694**
	(-1.765)	(-0.315)	(-1.136)	(-0.447)	(-3.852)
lngdp	0.050**	0.001	-0.123	-0.17	-0.285**
	(-3.255)	(0.024)	(-1.156)	(-1.168)	(-3.269)
gov	0.004	-0.090*	4.432	5.796	17.123**
	(-0.218)	(-2.483)	(0.694)	(0.974)	(4.419)
open	1.907	-7.001*	-17.605	0.915	-17.585
	(-1.63)	(-2.113)	(-1.930)	-0.138	(-1.284)
lnedu	-0.463**	-0.337*	-0.243	-0.512	-1.128**
	(-9.719)	(-2.194)	(-0.609)	(-1.288)	(-3.248)
R^2	0.777	0.856	0.783	0.947	0.803
Sample size	360	180	60	40	80

Note. t-values in brackets, * and ** denote 5% and 10% significance levels respectively.

5. Conclusions and recommendations

5.1 Conclusion

This study selects panel data of 18 provincial cities in Henan Province from 2001 to 2020 to verify the impact of industrial structure change on total factor productivity in Henan Province, and draws the following main conclusions through theoretical and empirical analysis. Firstly, the spatial variation of industrial structure change in Henan Province is more obvious. In general, the spatial variation of industrial structure rationalisation in Henan Province shows an overall increasing trend during 2001-2020, especially in the decade of 2005-2014 when the spatial variation of industrial structure change continued to expand with an annual growth rate of up to 10%. However, it is worth noting that the rate of expansion of spatial differences in industrial structural change slowed down in the period 2015-2019. More unlike the rationalisation of industrial structure, the spatial differences in the advanced industrial structure of Henan Province are generally more balanced during this period, and even show a decreasing trend after 2013. Second, there are differences in the effects of industrial structure rationalisation and industrial structure upgrading on total factor productivity within different regions. At the sample-wide level, the rationalisation of industrial structure promotes the increase of total factor productivity at a significant level of 5%, while the effect of advanced industrial structure on total factor productivity is not significant. At the sub-regional level, both the rationalisation of industrial structure and the advanced industrial structure in the Central Plains Urban Cluster have a significant effect on total factor productivity at the 5% level, with the rationalisation of industrial structure having a stronger effect on the economy than the advanced industrial structure; the rationalisation of industrial structure in both the North Henan Economic Zone and the West and Southwest Henan Economic Zones has a significant effect on total factor productivity. In the Yellow-Huai Economic Zone, industrial restructuring has a detrimental effect on total factor productivity at a significant level of 10%, while industrial restructuring is not significant. Finally, the examination by period reveals that the industrial structure change in Henan Province shows different significant features in different periods. Among them, industrial structure rationalisation becomes the main factor affecting total factor productivity in the periods 2001-2005 and 2016-2020, and promotes economic development at a significant level of 10%, while in the period 2006-2010 it has a hindering effect on total factor productivity. The period 2006-2010 shows a hindering effect on total factor productivity. The advanced industrial structure only showed a significant positive effect on total factor productivity in the period 2011-2015. This indicates that the intensity of the impact of industrial structure rationalisation on total factor productivity has increased and has gradually become the main influencing factor in increasing total factor productivity.

5.2 Recommendations

5.2.1 Promote factor market reform and efficient flow of production factors.

Promoting the effective combination of production factors and improving the allocation efficiency of

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production factors is an important guarantee for promoting high-quality economic development. It is necessary to give full play to the influence of land, capital, technology, data and driving factors on economic development, break the shackles of the past urban-rural dualistic system, alleviate the problem of regional talent loss, and promote better transformation of technology into productivity. In addition, it is necessary to promote the cross-regional and cross-sectoral flow of production factors to realize the optimal allocation of production factors in the region.

5.2.2 Create a collaborative development mechanism and build a regional cooperation platform.

The correct guidance of government policies has a pivotal role in promoting the change of industrial structure and the development of regional economy. Therefore, the government must create a mechanism and platform for regional collaborative development according to the actual development needs, formulate reasonable regional coordination planning, rely on regional collaboration to strengthen inter-regional industrial transfer and the introduction of talent exchange, and realize the transformation of regional comparative advantages to regional cooperation advantages.

5.2.3 Optimize science and technology innovation environment and enhance science and technology innovation capacity.

Through the establishment of science and technology innovation system, improve technological innovation incentive mechanism, create a favorable institutional environment and cultural atmosphere of science and technology innovation for enterprises or individuals, followed by a deeper optimization of science and technology resource allocation, integration of existing science and technology development funds and through government financial support to cultivate a number of high-tech enterprises with a sense of independent innovation and good industrial prospects. Only by closely combining science and technology with industrial development can technology be transformed into productivity to the greatest extent, making science and technology innovation a sustainable driving force for industrial upgrading.

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