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Research on the Transformation and upgrading of Manufacturing Industry from the Perspective of Digital economy and technological Innovation-- based on the empirical Analysis of Manufacturing Industry in Guizhou Province

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Abstract: This paper explores the effect and internal mechanism of the digital economy in promoting the transformation and upgrading of the manufacturing industry in Guizhou Province. Theoretical analysis shows that the digital economy can enable the transformation and upgrading of the manufacturing industry through three types of factors. Based on the panel data of Guizhou Province from 2013 to 2020, the improved entropy method is used to explore the specific impact of these three factors on the transformation and upgrading of traditional manufacturing. Through empirical research, it is found that all three factors can optimize the industrial structure of the manufacturing industry, among which the level of digital infrastructure has the greatest positive impact. Second, in terms of heterogeneity, it is found that the epidemic has accelerated the pace of digital transformation of the manufacturing industry to meet higher digital needs. Through the above analysis, policy recommendations are given for three types of factors.

Keywords: Digital economy; technology innovation; industrial structure;transformation and upgrading

1. Introduction

Manufacturing industry is the basic industry to promote the development of national economy, and it plays a vital role in the process of national development. The added value of China's manufacturing industry increased from 16.98 trillion yuan in 2012 to 31.4 trillion yuan in 2021, accounting for nearly 30 percent of the world from 22.5 percent, maintaining its position as the world's largest manufacturing country. However, in the process of rapid development, it has also faced some challenges, such as obvious shortcomings in key areas of technology and increasing international competition. It is in urgent need of transformation and upgrade to promote more reliable, healthy and sustainable development. The digital economy, with its digital information and knowledge, a new generation of information technology with strong leadership, penetration and integration, and interconnected information networks, penetrates into all aspects of traditional industries, modifying its technological innovation model and resource element characteristics.Moreover, the market demand structure has brought huge opportunities for the transformation and upgrade of China's manufacturing industry. In this context, the Chinese government has put forward a series of targeted development strategies. These strategic plans have laid a good foundation for the digital economy to promote the transformation and modernization of China's manufacturing industry.

Manufacturing Guizhou as one of the underdeveloped areas in the west, promoting new-type industrialization is the only way to realize its modernization. In 2021, Guizhou's annual industrial output value is expected to reach 1.57 trillion yuan, and the industrial added value above scale will increase by about 12% over the same period last year, ranking firmly in the "first square" of the country. Industrial added value accounts for 27% of the region's GDP, an increase of 1.2 percentage points over the same period last year. Promoting the high-quality development of the manufacturing industry is the top priority to realize the high-quality economic development in Guizhou. Manufacturing is the main supplier of service tools, equipment and materials for other industries in Guizhou's national economic system. Its advanced nature confirms the modernization of Guizhou's

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modern agriculture and modern service industries and determines the competitiveness of Guizhou's products in domestic and foreign markets. In terms of total economic volume, added value and contribution rate, the added value of electronic and communication equipment manufacturing, computer and office equipment manufacturing, aerospace vehicle and equipment manufacturing increased by 48.9%, 23.2% and 27.8% respectively; from the perspective of digital economy development, information transmission, software and information technology services, industrial investment increased by 71.0% over the same period of the previous year, 62.9 percentage points higher than the provincial investment growth rate. The development of the manufacturing industry determines the overall economic situation of Guizhou. As Guizhou province occupies an important geographical location in the eastern and western hubs, the development of its manufacturing industry has played a crucial role.

In the environment of digital economy, how to integrate technological innovation with traditional industries such as manufacturing and explore collaborative innovation mechanism and transformation and upgrading has become a new focus of the current research. Based on the panel data of 8 cities (states) in Guizhou Province from 2013 to 2020, this paper explores the factors and mechanisms that affect the transformation and upgrading of manufacturing industrial structure from the perspective of digital economy and technological innovation.

2. Literature and Research Hypothesis

The concept of "digital economy" was first proposed by Don Tapscott in the book "The Digital Economy: Promise and Peril in the Age of Networked Intelligence" published in 1995. In the following two decades, the digital economy has played an increasingly important role in overall economic growth. In Australia's National Digital Economy Strategy (2011) report, the digital economy is defined as a global network of economic and societal activities driven by information and communication technologies such as the Internet, mobile phones and sensor networks.

With the progress of network communication technology, not only the digital economic basic industries such as the Internet industry have risen rapidly and become the "emerging supplement" with the fastest economic and social growth, but also through the competition and integration among different industries, the digital economic basic industry can bring about profound changes in traditional industries and even the whole economic society, which will reshape the socio-economic form. Dekle and Vandenbroucke (2006) make a quantitative analysis of China's industrial structure by building a model, and their research results also confirm that the transformation and upgrading of industrial structure has a far-reaching impact on economic growth.

Through the collation of the literature, it is not difficult to find that in terms of the factors affecting the upgrading of industrial structure, the current relevant research is mainly focused on external factors such as digital application of enterprises within the manufacturing industry, technological innovation and optimization of the industrial chain among enterprises, as well as the macro environment, and they are all based on a certain point of the digital economy, but there are few studies on the upgrading of the manufacturing industry driven by the digital economy as a whole.Therefore, analyzing the mechanism by which the digital economy affects the transformation and modernization of the manufacturing industry is the focus of this research.

The "G20 Digital Economy Development and Cooperation Initiative" in September 2016 specifies the digital economy as covering major areas such as digital infrastructure, digital industries, and digital technology innovation. This paper will enter the theoretical analysis of these three aspects.

2.1 Digital infrastructure construction and manufacturing

As the foundation for the development of the digital economy, digital infrastructure construction will become an essential track for future international competition. A large amount of infrastructure investment and construction can enhance the level of coordination with production factors in the

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industry (Xi Enchong, 2013), thereby promoting the optimal allocation of related resources and improving production efficiency, which has a substantial impact on the development of traditional manufacturing. Digital infrastructure is primarily manifested in the construction of infrastructure such as information and communication networks, which are mainly composed of sensors, networks and other fundamental hardware.

From an industry point of view, some traditional manufacturing industries have obvious agglomeration characteristics, that is, forming industrial clusters and making full use of the advantages of clusters. According to the theory of innovation diffusion, knowledge spillover is an essential factor in the formation of industrial agglomeration (Chen Rong, 2016), but knowledge spillover is affected by the impact of spatial distance shows a characteristic of decay with the increase of distance. With the rise of digital technologies such as the Internet of things and cloud computing, digital infrastructure construction helps the industry break the shackles of space, achieve real-time transmission of information, and provide help for the formation of innovative advantages of manufacturing clusters.

In summary, the first hypothesis of this paper is:

H1: The level of digital infrastructure construction has a positive impact on the optimization of the manufacturing industry structure.

2.2 Digital industry and manufacturing

The information service industry is an industry with a comparatively high degree of digitization. It uses contemporary digital technologies such as computers and networks to collect, process and process existing digital information and distribute it to customers in the form of digital products. With the continuous progress of digital technologies such as computers and the Internet, the relationship between the digital industry represented by the information service industry and the manufacturing industry is getting closer and closer, and the two-way interaction is becoming more and more frequent, and there is a trend of integration (Zhou Zhidan, 2012). At the internal level of the manufacturing industry, the role of the information service industry is mainly reflected in the realization of technical solutions, especially in the aspects of manufacturing information data collection and manufacturing process optimization, to help manufacturing enterprises shorten the product research and development cycle, and improve the degree of automation and production efficiency. At the industrial level, the integration of the information service industry and the manufacturing industry has become a new trend. Information technology continues to infiltrate into the manufacturing industry, give full play to the advantages of industrial collaborative innovation, and promote the coupling and coordinated development among industries (Tao Changqi, 2015). In order to achieve the advanced transformation of the manufacturing industry.

In summary, the second hypothesis of this paper is:

H2: The development level of the digital industry has a positive impact on the optimization of the manufacturing industry structure.

2.3 Digital technology innovation, scientific research and manufacturing

In a sense, digital technology is the core of digital economy and the main engine to promote the development of digital economy. Similarly, the development of manufacturing industry is inseparable from technological innovation. Similarly, the development of the manufacturing industry is inseparable from technological innovation. At the level of the external environment of enterprises, the development and innovation of digital technologies such as the Internet and big data help manufacturing enterprises to broaden the breadth of acquiring cutting-edge knowledge, decrease information search costs and transaction costs, and at the same time enhance the efficiency of information and data collection. In addition, in order to reduce the impact of the epidemic, many enterprises gradually focus on the informationization, digitalization and intelligence of production and manufacturing, and accelerate the shift to digital development models such as "online operation", "Internet +", "intelligent manufacturing", "contactless distribution" and so on. At the

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same time, integrate its cutting-edge big data, Internet of things, artificial intelligence and other technologies to help enterprises achieve data innovation and intelligent manufacturing.

Based on the above theoretical analysis, the third hypothesis of this paper is put forward:

H3: The level of digital technology innovation and scientific research has a positive effect on the optimization of the manufacturing industry structure.

3. Research Design

3.1 Evaluation method and variable description

3.1.1 Improved entropy evaluation method

(1) Indicator description: Assuming that the year span is d, the number of cities is n, and the number of indicators is m, then X_ θ ij represents the jth indicator of city i in the θ th year.

(2) Standardization of indicators:

$$X'_{\theta ij} = \begin{cases} \frac{X_{\theta ij}}{X_{\theta jmax}} \\ \frac{X_{\theta jmin}}{X_{\theta ij}} \end{cases} \quad [1]$$

(3) Determination of index entropy value:

$$H_j = -k\sum_{\theta=1}^{d}\sum_{i=1}^{n}[Y_{\theta ij}\ln Y_{\theta ij}],\quad k = \frac{1}{\ln(dn)},\quad Y_{\theta ij} = \frac{X'_{\theta ij}}{\sum_{\theta=1}^{d}\sum_{i=1}^{n}X'_{\theta ij}} \quad [2]$$

Determination of the utility value of the indicator information:

$$G_j = 1 - H_j \quad [3]$$

Determination of indicator weights:

$$W_j = \frac{G_j}{\sum_{j=1}^{m}G_j} \quad [4]$$

Determination of comprehensive score:

$$Z_{\theta i} = \sum_{j=1}^{m}(W_j X'_{\theta ij}) \quad [5]$$

3.1.2 Variable Description

This paper mainly studies and analyzes the impact of the digital economy level on the optimization and upgrading of the manufacturing industry structure. Drawing on the research results of scholars, this paper sets the selected variables as follows:

(1) Explained variables:

Drawing lessons from the research method of Shen Yunhong (2020), this paper evaluates the optimization and upgrading level of manufacturing industrial structure based on manufacturing transformation and upgrading index. For manufacturing transformation and upgrading index (MTU), the ratio of tertiary industry output value to secondary industrial output value is used to calculate the upgrading of industrial structure.

(2) Explanatory variables:

The three dimensions of digital infrastructure construction level, digital industry development level and digital technology innovation and scientific research level are used to measure the regional digital economy development level.

Digital infrastructure construction level (Dig_infra), refer to the calculation method of Li Jie (2020), use the total number of telecommunication services, the number of mobile phone users and

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Internet broadband access ports, and use the improved entropy method to weight the indicators, The resulting comprehensive score represents the level of digital infrastructure construction.

The development level of digital industry (Dig_indus), drawing on Wei Yanqiu ' s (2020) calculation method, using the total GDP of information transmission, software and information technology service industries, the number of employees in the information service industry, and business income, using the improved entropy method to evaluate the indicators. Empowerment is carried out, and the comprehensive score obtained represents the level of digital infrastructure construction.

Digital technology innovation and scientific research level (Dig_techn). . Considering the availability of data and the previous theoretical analysis, based on the basic situation of Guizhou Province, the R & D funds and the total number of talents with bachelor degree or above are selected, and the improved entropy method is used for weighting. The comprehensive score obtained represents the scientific research level of digital technology innovation. The comprehensive score represents the level of digital technology innovation and scientific research. The index system is shown in Table 1.

Table 1. Index system of manufacturing transformation and upgrading from the perspective of digital economy

Target layer	Indicator layer	unit	Indicator properties
Digital infrastructure development level	Total telecom business	ten thousand	positive
	Number of mobile phone users	ten thousand	positive
	Internet broadband access port	ten thousand	positive
Digital industry development level	Information service industry investment	ten thousand	positive
	Employment in Information Services Industry	10,000 people	positive
	Information service business income	10,000 people	positive
Digital technology innovation and scientific research level	R&D R&D spending	ten thousand	positive
	The total number of talents with bachelor degree or above	10,000 people	positive

(3) Considering the influence of other factors on the optimization and upgrading of manufacturing industrial structure, the control variable of this paper mainly selects the level of economic development (ED), expressed by per capita GDP; the degree of government participation (GI), using the ratio of expenditure in the general budget of local finance to GDP, the degree of dependence on foreign trade (FTD), and the ratio of total import and export to GDP. Educational Input Level (ETL) The ratio of the sum of local financial scientific and educational expenditures to the expenditures in the general budget of the local finance represents the level of educational investment.

3.2 Model Construction

This paper mainly investigates the impact of the digital economy level on the optimization and upgrading of the manufacturing industry structure. Therefore, the model is set as follows:

$$Dig\_R = \beta_0 + \beta_1 MTU_{i,t} + \beta_x \sum Control_{i,t} + \gamma_i + \delta_t + \varepsilon_{i,t} \quad [6]$$

$$(\mathrm{R} = \mathrm{infra、indus、techn})$$

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Among them, MTU represents the optimization and upgrading of the manufacturing industry structure of I cities (prefectures) in Guizhou Province in year t. Dig_infra, Dig_indus and Dig_techn respectively represent the digital infrastructure construction level, digital industry development level and digital technology innovation of I cities (prefectures) in Guizhou Province in year t. research level. Control represents a collection of control variables, including the level of economic development (ED), government involvement (GI), foreign trade dependence (FTD) and schooling input level (ETL). β_x represents the response coefficient of the explained variable to each control variable, $\varepsilon_{(i,t)}$ is the random interference term, Y_i is the regional effect, and δ_t is the time effect.

3.3 Data sources

In this paper, the source of empirical data collection mainly comes from Wind database and Guizhou Statistical Yearbook, and selects Guizhou provincial (state) panel data from 2013 to 2020 as the research sample. In order to eliminate the influence of heteroscedasticity, 1 this paper makes logarithmic processing on the index data of absolute quantities in the variables involved in the empirical analysis. 2 deal with all continuous variables by tail reduction, and the quantile standard is 1% and 99%. First of all, we make a descriptive statistical analysis of the variables, and the following table shows the results of the descriptive statistical analysis of the variables needed in this paper. The total sample size of each variable in the empirical analysis is 72.

Table 2. Descriptive Statistics：

variable	N	mean	sd	min	max
Dig infra	72	0.377	0.263	0.034	0.812
Dig indus	72	0.400	0.341	0	0.912
Dig techn	72	0.423	0.334	0	0.925
MTU	72	1.395	0.445	0.636	2.662
Ed	72	10.44	0.382	9.677	11.31
GI	72	0.301	0.081	0.157	0.476
FTD	72	0.118	0.198	0.027	0.635
FIL	72	14.02	0.771	12.62	14.90

Table 2 presents the descriptive statistical analysis of the variables:

(1) The maximum value of the digital infrastructure construction level of the 8 municipalities (prefectures) in Guizhou Province is 0.812, the minimum value is 0.0340, and the average value is 0.222. The development level of digital industry is 0.912, the minimum is 0, and the average value is 0.210. The maximum value of scientific research level of digital technological innovation is 1, the minimum value is 0, and the average value is 0.925. In order to show that the overall development of digital economy in Guizhou Province is good in recent years, the industry has developed steadily.

(2) The manufacturing transformation and upgrading index (MTU) of 8 towns (prefectures) in Guizhou Province. The manufacturing transformation and upgrading index (MTU) of the nine municipalities (prefectures) in Guizhou Province has a maximum value of 2.622, a minimum value of 0.636, and a standard deviation of 0.445, implying that the manufacturing industry competition in the eight cities (prefectures) in Guizhou Province is generally intense.

(3) The average values of economic development level (ED), government participation degree (GI), foreign trade dependence degree (FTD) and education investment level (ETL) in 8 cities (states) of Guizhou province are 10.44,0.301, 1.867 and 14.02 respectively, and the minimum values are 9.677, 0.157, 1.513 and 12.62.This shows that there is a big gap in the economic development level and education investment level of the eight cities (states) in Guizhou province.

3.4 Correlation analysis

In this paper, Pearson correlation coefficient analysis is used to test the relationship between digital economy and the optimization and upgrading of manufacturing industrial structure, and the

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main variables in the model are also analyzed. The Pearson correlation coefficient is shown in the Pearson correlation coefficient matrix in tables 4, 5 and 6.

Table 3. Dig_infra correlation coefficient matrix

	Dig_infra	MTU	ED	GI	FTD	EIL
Dig_infran ~ainfra	1					
MTU	0.337***	1				
ED	0.484***	-0.0660	1			
GI	-0.110	0.585***	-0.757***	1		
FTD	-0.557***	-0.201*	-0.366***	0.155	1	
EIL	-0.492***	-0.160	-0.117	-0.00800	-0.0880	1

Table 4. DIg_indus correlation coefficient matrix

	Dig_indus	MTU	ED	GI	FTD	EIL
Dig_indusn	1					
MTU	0.331***	1				
ED	0.474***	-0.0660	1			
GI	-0.0970	0.585***	-0.757***	1		
FTD	-0.504***	-0.201*	-0.366***	0.155	1	
EIL	-0.530***	-0.160	-0.117	-0.00800	-0.0880	1

Table 5. Dig_techn correlation coefficient matrix

	Dig_techn	MTU	ED	GI	FTD	EIL
Dig_techn	1					
MTU	0.336***	1				
ED	0.488***	-0.0660	1			
GI	-0.105	0.585***	-0.757***	1		
FTD	-0.543***	-0.201*	-0.366***	0.155	1	
EIL	-0.479***	-0.160	-0.117	-0.00800	-0.0880	1

This paper contains one explained variable, three explanatory variables and four control variables. In order to avoid the problem of multicollinearity before variables and ensure the accuracy and scientific nature of the empirical results, the relationship between variables is judged by calculating the Pearson correlation coefficient before each variable.In general, if the absolute value of the Pearson - coefficient is less than 0.8, there is no multicollinearity. On the contrary, if it is greater than 0.8, there is a serious collinearity problem and one of the variables should be eliminated.

4. Empirical Results and Analysis

4.1 Benchmark regression analysis

This paper analyzes the impact of the digital economy level on the optimization and upgrading of the manufacturing industry structure by establishing a model. The specific empirical results are as follows:

Table 6. Benchmark regression analysis results

	Model [1]		Model [2]		Model [3]	
	a1	a2	a3	a4	a5	a6
VARIABLES	RE	FE	RE	FE	RE	FE
Dig_infra	0.635***	1.050***				
	(3.297)	(5.423)				
Dig_indus			0.427***	0.760***		
			(2.833)	(4.975)		
Dig_techn					0.492***	0.859***
					(3.234)	(5.609)
ED	-1.45e-06	-1.72e-05***	-3.24e-08	-1.66e-05***	-2.29e-06	-2.01e-05***
	(-0.271)	(-2.945)	(-0.00581)	(-2.698)	(-0.407)	(-3.288)
GI	2.749***	0.716	2.849***	0.417	2.604***	0.357
	(3.155)	(0.739)	(3.162)	(0.412)	(2.907)	(0.367)
FTD	-0.193	-0.179	-0.261*	-0.259*	-0.229	-0.229*
	(-1.267)	(-1.343)	(-1.739)	(-1.924)	(-1.540)	(-1.758)
EIL	0.00880	0.0411	0.00433	0.0428	0.00149	0.0353
	(0.231)	(1.244)	(0.108)	(1.217)	(0.0403)	(1.115)
Constant	0.280	0.859	0.337	1.006*	0.492	1.194**
	(0.453)	(1.541)	(0.536)	(1.770)	(0.811)	(2.220)
Hausman		147.14			1244.85	183.26
		(0.000)			(0.000)	(0.000)
Observations	72	72	72	72	72	72
R-squared	0.553	0.593	0.543	0.570	0.524	0.602

Source: Arranged according to the estimation results of stata15;

Note: Values in brackets are T values. ***, **, * denote the significance levels of 1%, 5% and 10%, respectively.

Table 6 shows the results of the benchmark regression analysis. It can be seen from the human statistics that digital infrastructure construction, digital industry development and digital technology innovation and scientific research all reject the null hypothesis (H0: the model has random effects). Therefore, fixed effects are selected for regression testing in this paper.

According to the regression results of model [1] in Table 6, the regression coefficient of digital infrastructure construction level is 1.050, which means that for every 1% increase in digital infrastructure construction level, the degree of transformation and upgrading of manufacturing industry in Guizhou Province increases by 0.0105, indicating that there is a positive correlation between the level of digital infrastructure construction and the transformation and upgrading of manufacturing industry. Increasing investment in digital infrastructure construction and improving its level will help to optimize the manufacturing industrial structure of Guizhou Province, so hypothesis 1 has been verified.

According to the results of the model [2] in the table, the regression coefficient of the development level of the digital industry is 0.760, which means that for every 1% increase in the level of digital infrastructure construction, the degree of transformation and upgrading of the manufacturing industry in Guizhou Province increases by 0.0076. It shows that there is a positive correlation between the development level of digital industry and the transformation and upgrading of manufacturing industry, therefore， hypothesis 2 is verified. This is because the current

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technology application is still in the development and design stage, the breadth and diversity of applications are gradually increasing, and a key in-depth role has not yet been formed.

According to the results of model [3] in the table, the regression coefficient of digital technology innovation and scientific research level is 0.859, passing the 1% significance level, that is, for every 1% increase in the level of digital infrastructure construction, the degree of transformation and upgrading of the manufacturing industry in Guizhou Province increases by 0.00859. It shows that the level of digital technology innovation and scientific research is positively correlated with the transformation and upgrade of the manufacturing industry, so Hypothesis 3 is verified. For Guizhou Province has implemented a major breakthrough in the digital industry to speed up the construction of three trillion-level industrial clusters, such as data centers, intelligent terminals and data applications. Speed up the cultivation of a new generation of information technology enterprises in six major areas, such as artificial intelligence, 5G, Internet of things, cloud computing, blockchain, and information security, to enhance the competitiveness of Guizhou database, cloud desktop, data security and other products.

Comparing the results of the three models, we can find that under the background of vigorously advocating digital economy, the level of digital infrastructure construction, the development level of digital industry and the scientific research level of digital technology innovation are constantly improving. promote the transformation and upgrading of the manufacturing industry to varying degrees. Digital infrastructure is the underlying foundation of the digital economy. As the carrier of information, digital infrastructure plays a significant role in optimizing the manufacturing industry. The empirical results also prove that the level of digital infrastructure has the greatest impact on promoting the transformation and upgrading of the manufacturing industry.

4.2 Heterogeneity analysis

At the end of 2019, the new crown epidemic swept the world, and my country's real economy suffered a huge impact. The digital economy industry in Guizhou Province has penetrated into various industries, further optimizing the industrial structure of the manufacturing industry. To explore the specific impact effect, this paper divides it from the time dimension and then conducts regression tests.

Table 7 Heterogeneity results

	Model [4]		Model [5]		Model [6]	
	a7	a8	a9	a10	a11	a12
VARIABLES	Before the epidemic	post-pandemic	Before the epidemic	post-pandemic	Before the epidemic	post-pandemic
Dig_infra	0.578***	0.491***				
	(6.303)	(8.192)				
Dig_indus			0.450***	1.756***		
			(5.867)	(8.192)		
Dig_techn					0.443***	0.926***
					(6.266)	(8.192)
Controll	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	1.178***	1.238***	1.219***	0.0356	1.207***	0.781***
	(41.75)	(27.68)	(50.02)	(0.186)	(48.88)	(7.770)
Observations	54	18	54	18	54	18
R-squared	0.474	0.893	0.439	0.893	0.472	0.893
Number of id	9	9	9	9	9	9

Source: Arranged according to the estimation results of stata15;

Note: Values in brackets are T values. ***, **, * denote the significance levels of 1%, 5% and 10%, respectively.

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Table 7 shows the results of heterogeneity analysis. In the construction of digital infrastructure, the marginal utility decreased after and before the epidemic (column (1) β = 0.578; column (2): β = 0.491). This is because the construction of digital infrastructure requires direct human contact, but due to avoiding offline crowds during the epidemic, there has been a delay in this construction, but can significantly improve the optimization and upgrading of the industrial structure of the manufacturing industry.In terms of the development of the digital industry, the marginal utility grew after the epidemic and before the epidemic (column (3): β=0.450; column (4): β=1.756). This is because working from home has become the norm during the epidemic, which has made the digital economy more infiltrated into the tertiary industry, which is still promoting the optimization of the manufacturing industry structure. In terms of digital technology innovation and scientific research, the marginal utility grew after the epidemic and before the epidemic (column (5): β=0.443; column (6): β=0.926). This is because the public's demand for the digital life experience of the digital economy continues to grow, which promotes continuous technological innovation. In the future, more programs will be deployed in the cloud, which will still promote the optimization of the industrial structure of the manufacturing industry.

Generally speaking, while the COVID-19 epidemic has an impact on the economy, we should also see that it also enables the transformation and application of more information technology achievements, such as some unmanned logistics distribution devices. This provides convenient conditions for the accelerated integration of artificial intelligence, 5G, Internet of things and other new technologies, so as to be deeply applied to more industries and fields.

4.3 Robustness check

After reading a lot of literature, this paper draws on the research method of Shen Yunhong (2020), and conducts robustness test in the decreased sample data passed. Models (1), (2), (3) are assessed. The results are as follows in Table 8:

Table 8. Reduced sample regression results

	Model [7]	Model [8]	Model [9]
	a13	a14	a15
VARIABLES	MTU	MTU	MTU
Dig_infra	0.570***		
	(8.002)		
Dig_indus		0.432***	
		(7.738)	
Dig_techn			0.447***
			(7.960)
Controll	*Yes*	*Yes*	*Yes*
Constant	1.180***	1.222***	1.206***
	(36.12)	(41.79)	(39.92)
Observations	72	72	72
R-squared	0.508	0.491	0.505
Number of id	9	9	9

Source: Arranged according to the estimation results of stata15;

Note: Values in brackets are T values. ***, **, * denote the significance levels of 1%, 5% and 10%, respectively.

Table 8 shows the reduced sample analysis results. It can be seen from the above table that digital infrastructure construction, digital industry development, digital technology innovation and

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scientific research and the manufacturing transformation and upgrading index are still significantly positively correlated. Column (1): β=0.570, β=0.432; Column (3) β=0.447, the coefficients are consistent with the original sample regression coefficients. It can be obtained by the size of the coefficients, and the numerical order is consistent with the results of the original model. Therefore, the original model results are robust.

5. Conclusions, recommendations and deficiencies

5.1 Conclusion

Through theoretical analysis, this paper explores three important factors driving the optimization and upgrading of manufacturing industrial structure under the background of digital economy, and then establishes the corresponding evaluation index system and uses the improved entropy method to measure the variables. finally, the panel data of 8 cities (states) in Guizhou Province from 2013 to 2020 are collected, and the fixed effect model is used to analyze empirically under the background of digital economy. The influence of the construction level of digital infrastructure, the development level of digital industry and the scientific research level of digital technology innovation on the optimization and upgrading of manufacturing industrial structure. The empirical results show that the construction level of digital infrastructure, the development level of digital industry and the scientific research level of digital technology innovation all play an obvious role in optimizing the industrial structure of manufacturing industry, promoting its development to a technology-intensive direction. Among them, the level of digital infrastructure plays the most positive role.

5.2 Policy Recommendations

Stabilize basic industries and enhance digital infrastructure construction. Invest heavily in the construction of digital infrastructure such as the Internet, the Internet of Things, cloud computing and big data to promote the development of information technology. Focus on weak points, upgrade and transform urban and rural industrial broadband networks and improve the level of basic software and hardware facilities. Actively analyze new cross-regional models of joint construction and sharing and promote traditional manufacturing industries to improve production efficiency and business model innovation.

Deploy future industries and promote the development of new digital industries. Promote the combination of digital technology and manufacturing technology and in-depth research and development of intelligent equipment. Facilitate the digital transformation of traditional industries, rely on the digital empowerment platform, coordinate with digital resources, and promote the interactive development of all links in the industrial chain. With digital technology as the core, increase investment and create a more open, inclusive and collaborative digital ecosystem.

Accelerate the construction of innovation platforms and strengthen technological innovation capabilities. Relying on international exchange platforms such as Ecological Civilization Guiyang International Forum, and China International Big Data Industry Expo, analyze the establishment of an international industrial collaborative innovation platform. Focusing on key areas such as artificial intelligence and network data security, strive to break through key technologies and form independent innovation achievements. Actively explore the integration of industry and city, and urge science and technology parks such as Gui'an New District and Guiyang National High-tech Industrial Development Zone to explore and establish collaborative innovation mechanisms and models for integration of industry and city.

5.3 Deficiencies

There are still some shortcomings in this study. In view of the low degree of disclosure and availability of county-level data, the evaluation index system of explanatory variables needs to be expanded and supplemented to make it more representative. And the geographical location of

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Guizhou Province may be affected by the surrounding environment, taking into account the surrounding provinces or cities of technology, science and technology spillover effects is also one of the future research directions.

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