

Research on the Role Mechanism of Digital Economy on Industrial Transformation and Upgrading in Jiangxi Province

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Abstract: High-quality development is the primary task of building a modern socialist country in a comprehensive manner. After decades of development, the digital economy has realised a wide range of connotations and diversified technological applications at the theoretical and practical level. This project constructs digital economy-enabled industrial high-quality development indicators from multiple dimensions, and explores the intrinsic mechanism of digital economy and industrial transformation and upgrading in 11 prefecture-level cities in Jiangxi Province. Specifically, the entropy weight-TOPSIS model is established to measure the comprehensive score of digital economy and the level of industrial structure transformation and upgrading of the two, and the PVAR model is constructed to further explore the mechanism of the two. The study found that in the comprehensive level of the digital economy, the overall trend is rising, and the difference in the level of digital economic development of each city is getting bigger and bigger; in the comprehensive level of industrial transformation and upgrading, the overall view of the various cities in Jiangxi Province with the change of time, industrial transformation and upgrading level is gradually improved; through the establishment of the PVAR model analysis of the impact of the digital economy on the upgrading of the industrial structure is not particularly obvious, and the impact of the level of the industrial structure on the the impact of the digital economy is unstable. In this regard, this paper puts forward specific suggestions in three aspects: encouraging the vigorous development of digital economy, accelerating the pace of industrial transformation and upgrading, and stimulating the power of digital economy on industrial transformation and upgrading.

Keywords: Digital economy; Industrial transformation and upgrading; Pvar model.

1. Introduction

In recent years, China's industrial economy has been developing continuously, the scale of industry has been expanding the level of industrial technology has been rapidly upgraded and the gap between China and developed countries has been gradually narrowed by focusing on upgrading the level of industrial technology and innovation capacity. According to its own actual situation and development stage changes, China has continuously deepened reform and opening up, continuously adjusted its industrial development strategy, and walked out of a road of industrial development and structural upgrading in line with China's national conditions and with Chinese characteristics. Today, the industrial economy has become the main force driving China's economic development.

Since the 18th National Congress of the CPC, China has attached great importance to the important role of the digital economy in economic development, and has successively issued the Digital Economy Development Strategy and the 14th Five-Year Plan for the Development of the Digital Economy, and the relevant departments have actively implemented the relevant policies and regulations to promote the advancement of digitisation and the digital transformation of industries, so as to facilitate the vigorous development of the digital economy. Over the years, China's digital economy has made remarkable achievements, and the overall development scale has ranked second in the world for many years. At the same time, the digital economy has also contributed to the development of China's industries, such as accelerating the enhancement of China's industrial innovation

capacity, the digital transformation of industries, and promoting the digitalisation of the public service industry. In the 13th National People's Congress, the CPC Central Committee and the State Council have also pointed out the need to accelerate and deepen the digital transformation of industries, and to unleash the amplifying, superimposing and multiplying effects of digital on economic development. The transformation and upgrading of China's industries urgently need new forces to support, and the digital economy to guide the transformation and upgrading of the industrial structure of the dominant role of information technology, can make use of the diffusion of information technology, penetration, fusion and innovation and other characteristics, to achieve the digital transformation of traditional industries, which has become an inevitable choice to promote the transformation and upgrading of the industrial structure.

2. Literature Review at Home and Abroad

2.1. Connotation of digital economy

After decades of development, the digital economy has achieved a wide range of coverage and the application of multiple technologies at both the theoretical and practical levels, giving rise to the vigorous development of new industries and promoting the transformation and upgrading of traditional industries. The definition of digital economy varies according to the perspective chosen, but all of them agree that digital economy takes modern information technology as a carrier and makes great use of data elements in various sectors and industries. Official and scholarly definitions of the digital

economy in theory cover all the nuances, The 2020 G20 Saudi Arabia meeting [1] proposed a consensus definition of the digital economy in the *G20 Roadmap Towards a Common Framework for Digital Economy Measurement*: Aggregate economic activities that depend on or significantly benefit from a range of infrastructure, technology, services and data provided by digital inputs from producers and consumers, including the government. Zhang Liangliang et al. (2018)[2] argued that the digital economy revolves around digital information as the core, relying on information networks and technologies to provide digital products and services, and is a new economic form in which industries, technologies, and producers and consumers are integrated.

2.2. Demand for industrial transformation and upgrading

Industrial transformation and upgrading includes both industrial transformation and industrial upgrading, which is a combination of resource reallocation and resource renewal process. China's transformation and upgrading mechanism was initially a reform measure that fell into the field of reform and opening up in 1992, followed by the Third Plenary Session of the 18th Central Committee in 2013, which put forward the overall requirements for industrial transformation and upgrading to a more favourable economic and social development. Although there is a further understanding of industrial transformation and upgrading after the financial crisis in 2008, Tian Xuebin et al. (2019)[3] believe that in recent years, both the international "anti-globalisation", "re-industrialisation" and "manufacturing reflux" have been constantly changing. The complex situation of "reverse globalization", "re-industrialisation" and "manufacturing reflux" on the international scene, or the upgrade of people's higher needs and the requirements of high-quality economic development on the domestic scene, the demand for the transformation and upgrading of China's economic structure is very urgent, and it is in the important critical period of the transition across the hurdles. Shi Yong (2018)[4] believes that as early as 2017, under the standard of Qian Nari on the division of the development stage of industrialisation, Jiangxi has been in the mid-stage of industrialisation development of attacking and speeding up the transformation and upgrading of industries, and further exploration of the transformation and upgrading of industries in Jiangxi Province needs to be continuously promoted.

2.3. Exploration of Role Mechanisms

The basis for launching the research on the role mechanism between digital economy and industrial transformation and upgrading is to have a clear definition and measurement of digital economy and industrial transformation and upgrading. Jiang Xingming (2014)[5] argues that the connotation of industrial transformation and upgrading includes the transformation and upgrading of the production factor combinations of the industrial chain, value chain, and innovation chain. Wang Jun et al. (2021)[6] start from the conditions, applications and environment of the digital economy, and construct a total system to measure the digital economy with four major indicators of digital economy development carrier, digital industrialisation, industrial

digitisation, and digital economy development environment, as well as its subordinate 9 indicators and 30 variables. Li Chunfa (2020)[7] theoretically illustrated the transformation and upgrading mechanism of the digital economy driving the division of labour, transaction costs, value distribution and demand changes in the manufacturing industry organisation from the perspective of the industrial chain. Meanwhile, empirically, Li Zhiguo et al. (2021) [8] constructed an econometric model to explain the level of transformation and upgrading of the industrial structure with the level of digital economy development, which illustrated that the digital economy promotes the speed of China's three industries tilted towards the secondary and tertiary industries, and that there are heterogeneous differences in the region. Liu Vanadium (2023) [9] also analysed the digital economy driving force of national industrial transformation and upgrading demonstration zones including Pingxiang, Jiangxi with the help of econometric model, and found that there is a difference in the digital economy driving force between the old industrial cities and resource-based cities. And Huang Ping (2022) [10] based on Jiangxi Province believes that local governments have an important role in promoting industrial transformation and upgrading in the context of digital economy.

2.4. Analytical Review

Digital economy as a new dynamic new industry, its wide radiation impact has been widely researched, in which there is no lack of connotation of clear and indicator measurement of professional discourse. Many scholars have their own profound insights into the correction of industrial development misconceptions in industrial transformation and upgrading. However, most of the literature tends to analyse the driving effect of digital economy on industrial transformation and upgrading from a macro perspective, such as the national scope and the scope of the city circle, but the empirical measurement of the intensity of the effect, especially based on the research in specific provinces, is still insufficient. Only with a clear scientific representation of the mechanism of its role can we analyse the extent of the deviation from the misconceptions and take corresponding policy measures to correct the errors and promote the sustained and high-quality development of the economy and society.

3. Measurement of Digital Economy and Industrial Upgrading Level

3.1. Selection of digital economy indicators

Combined with the scholars on the establishment of indicators for measuring the digital economy, analyse the advantages and disadvantages of each indicator establishment method after comprehensive consideration, this paper will be subdivided into 12 tertiary indicators from four aspects of the digital economy infrastructure, application level, industrial support and development environment, comprehensive statistics to measure the level of development of the digital economy of the eleven prefectural-level cities in Jiangxi Province, and ultimately build the digital economy development level indicator system, as shown in Table 1.

Table 1. Digital economy indicator system

Primary Indicators	Secondary Indicators	Secondary Indicators
Level of digital economy development Digital economy	Digital economy infrastructure	Long-distance fibre-optic lines
		Number of domain names
		Broadband Access Ports
	Level of application of the digital economy	Number of Internet users
		Number of websites
		Domain Name Holdings
	Digital economy industry support	Revenue of Information Service Industry
		Total Telecommunications Business
		Software Product Revenue
	Digital economy development environment	Investment in Education
		Number of university students
		Internal Expenditure on R&D Funds

3.2. Selection of indicators for industrial transformation and upgrading

shown in Table 2:

Indicators of industrial transformation and upgrading are

Table 2. Indicators of industrial transformation and upgrading

Primary Indicators	Secondary Indicators	displayed formula
Industrial transformation and upgrading	Highly structured industry	$\frac{Y_3}{Y_2}$
	Upgrading of industrial structure	$\sum_{i=1}^3 y_i \times i = y_1 \times 1 + y_2 \times 2 + y_3 \times 3$
	Rationalisation of industrial structure	$\frac{1}{\sum_{j=1}^N (\frac{Y_j}{Y_i}) \times LN(\frac{Y_{ij}}{Y_i} / \frac{Y_i}{L_i})}$

3.3. Measurement method-entropy weight TOPSIS method

Entropy weight method is a kind of objective assignment method proposed by information scientist Shannon, the basic principle is that, according to the degree of dispersion of the data of each indicator to calculate the entropy weight of each indicator, the entropy weight can be obtained after correction of the more objective indicator weights. TOPSIS method, can make full use of the information of the original data to carry out a comprehensive evaluation, and the evaluation results are very accurate in the reflection of the differences between the indicators. The combination of entropy weight method and TOPSIS method can be more objective to arrive at the comprehensive evaluation score of each indicator.

For an indicator z_{ij} , The information entropy is calculated as:

$$E_j = -\frac{1}{\ln(n)} \sum_{i=1}^n p_{ij} \ln p_{ij} \quad (1)$$

included among these

$$p_{ij} = \frac{z_{ij}}{\sum_{j=1}^5 z_{ij}} \quad (2)$$

If the information entropy of an indicator E_j smaller, the greater the degree of variability and the greater the amount of information provided, and the greater the role of the indicator in the comprehensive evaluation.

The weights of the indicators were calculated as:

$$\omega_{ij} = \frac{(1 - E_j)}{\sum_{j=1}^5 (1 - E_j)} \quad (3)$$

The entropy weight method is improved by incorporating the weighted TOPSIS method into the calculation of the total score and using the entropy weights as the weights, the principle of the weighted TOPSIS method is as follows:

step1: Harmonisation of monotonicity across evaluation indicators

step2: Constructing a comprehensive evaluation matrix

Weighting by indicator $c_j (j=1,2,3...n)$ as weight

$$\sum_{j=1}^n c_j = 1$$

step3: Establishment of a normative multi-objective decision matrix

$$t_{ij} = \frac{s_{ij}}{\sqrt{\sum_{i=1}^m s_{ij}^2}}, (i=1,2...m, j=1,2...n) \quad (4)$$

step4: Obtain the optimal value vector and the worst value vector from the matrix.

$$T^+ = (t_1^+, t_2^+ \dots t_m^+) \quad (5)$$

$$T^- = (t_1^-, t_2^- \dots t_m^-) \quad (6)$$

included among these, $t_j^+ = \max_{1 \leq i \leq m} (t_{ij}), t_j^- = \min_{1 \leq i \leq m} (t_{ij}), j = 1, 2, \dots, n$

step5: Calculation of the distance of each evaluation object from the optimum and the worst value

$$d_i^+ = \sqrt{\sum_{j=1}^n c_j (t_{ij} - t_j^+)^2} \quad (7)$$

$$d_i^- = \sqrt{\sum_{j=1}^n c_j (t_{ij} - t_j^-)^2} \quad (8)$$

step 6: Calculation of the relative proximity of each evaluation object to the optimal and worst values

3.4. Analysis of the comprehensive level of digital economy

In this paper, MATLAB is used to solve and get the score of the comprehensive level of digital economy of 11 cities in Jiangxi Province, as shown in Figure 1:

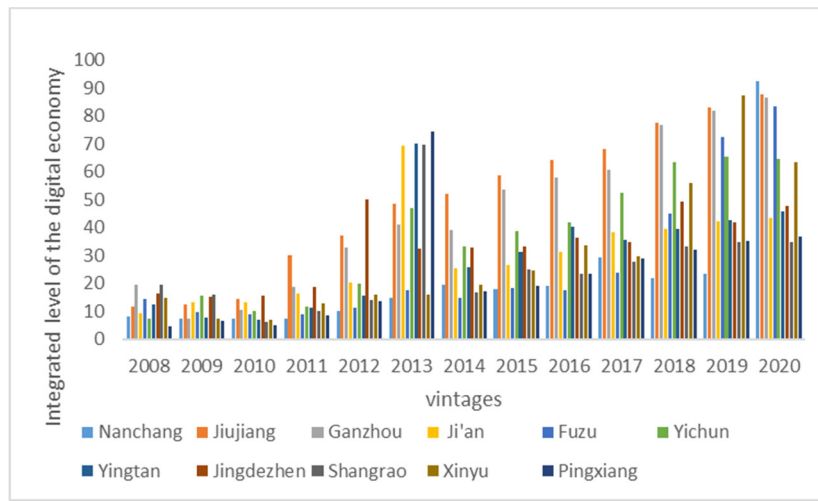


Figure 1. Digital Economy Score of 11 Cities in Jiangxi Province

From a provincial perspective, the comprehensive level of the digital economy is still on the rise overall, although it declined in 2009-2010 and 2013-2014 in some cities, while the differences in the level of digital economy development among cities are growing with the development of the times.

3.5. Comprehensive level analysis of industrial transformation and upgrading

This paper uses MATLAB to solve, in order to facilitate the comparison of the development level of industrial transformation and upgrading between different cities, the above score data is normalised, the results are shown in Figure 2:

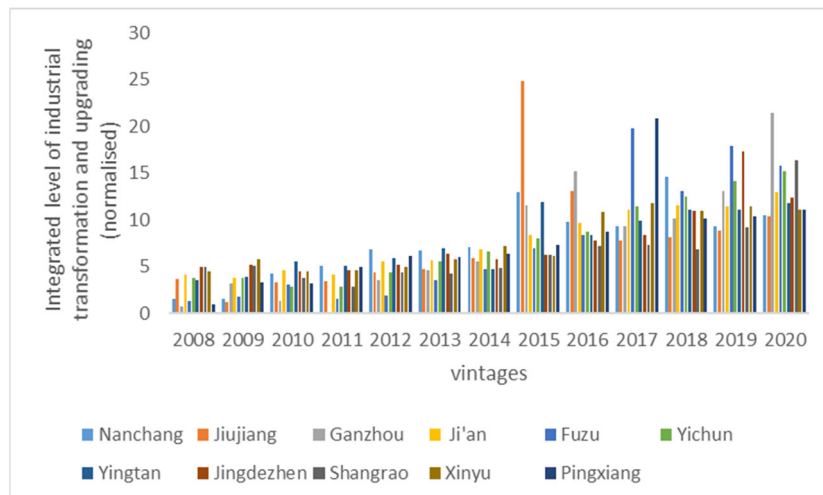


Figure 2. Normalised industrial transformation and upgrading score by city

After normalisation it can be seen that the level of industrial transformation in all cities in Jiangxi Province is improving, with an excellent trend. However, a careful analysis of the level of industrial transformation and upgrading in 2020 shows that the overall level is still low, concentrating between 10 and 20 per cent, indicating that the industry of each city still needs to be upgraded.

4. Empirical Analysis

4.1. Descriptive Statistics

We firstly analyse the descriptive statistics of the panel data of the corresponding digital economy and industrial structure levels of 11 cities in Jiangxi Province from 2008 to 2020, and the results are shown in Table 3.

Table 3. Descriptive statistics

Variable Name	Number of Variables	Mean	Median	Maximum value	Minimum value
Digital Economy Index(SZJJ)	143	0.3183	0.2524	0.9256	0.0447
Industrial transformation and upgrading index(CYSJ)	143	0.3939	0.3371	0.9999	0.0002

4.2. Smoothness test

In this paper, the unit root is used to affect the smoothness of the series to prevent pseudo-regression in the regression analysis. Table 3 shows that the selected data of digital economy and industrial structure level are smooth in the case of containing the trend term and intercept term, and the PVAR model is established directly without the need of cointegration test to further test the data.

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Table 4. Smoothness test

Variable	Test Methods	Statistic	Prob.**
SZJJ	LLC	-4.35817	0.0000
	IPS	-2.50479	0.0061
	ADF-Fisher	42.7522	0.0051
	Fisher-PP	60.7191	0.0000
CYSJ	LLC	-6.26140	0.0000
	IPS	-2.15670	0.0155
	ADF-Fisher	40.7801	0.0088
	Fisher-PP	39.1002	0.0137

4.4. Determination of optimal order

After the smooth post-test of the data, the exploration and confirmation of the order of the model is carried out in this

paper. As shown in the figure, the second order is the most suitable lag order for the model according to the AIC and SC criteria.

Table 5. Lag order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	23.69937	NA	0.002311	-0.394534	-0.345434	-0.374619
1	91.21435	131.3473	0.000728	-1.549352	-1.402053*	-1.489607
2	99.23559	15.31327*	0.000677*	-1.622465*	-1.376967	-1.522890*
3	102.6972	6.482726	0.000684	-1.612677	-1.268980	-1.473271

The final modelling results are shown below:

Table 6. Modelling equations

SZJJ		CYSJ	
Variable	ratio	Variable	ratio
SZJJ(-1)	0.5037 (0.0950)	SZJJ(-1)	0.0375 (0.0970)
SZJJ(-2)	0.2774 (0.1046)	SZJJ(-2)	0.168536 (0.1067)
CYSJ(-1)	-0.0015 (0.09553)	CYSJ(-1)	0.5711 (0.09746)
CYSJ(-2)	0.1912 (0.1001)	CYSJ(-2)	0.2118 (0.1021)
C	0.0601 (0.0309)	C	0.0841 (0.0315)

$$SZJJ = 0.503744 * SZJJ(-1) + 0.277481 * SZJJ(-2) - 0.001521 * CYSJ(-1) + 0.191299 * CYSJ(-2) + 0.060171$$

$$CYSJ = 0.037590 * SZJJ(-1) + 0.168536 * SZJJ(-2) + 0.571168 * CYSJ(-1) + 0.211804 * CYSJ(-2) + 0.084132$$

4.5. Granger causality test

In order to explore whether the digital economy is an endogenous factor causing changes in the level of industrial structure, we conducted Granger causality test on the

relationship between the two. Table 7 can be concluded that the p-value is less than 0.05 and the original hypothesis is rejected, which indicates that the digital economy is a Granger cause of the level of industrial structure and has an impact on the change of industrial structure.

Table 7. Granger causality test

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
CYSJ does not homogeneously cause SZJJ	10.2894	4.65274	3.E-06
SZJJ does not homogeneously cause CYSJ	16.1938	8.42137	0.0000

4.6. Model smoothness test

The results of the model smoothness test are shown in

Figure 3, all the characteristic roots of the model fall within the unit circle, which indicates that the model established is smooth.

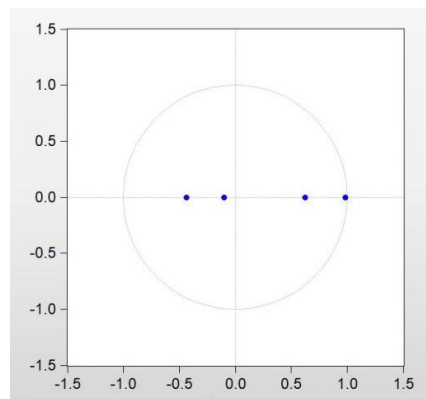


Figure 3. Unit circle test

4.7. Impulse response

This paper in the model established on the basis of the use of impulse response to explore the mutual influence between the digital economy and the level of industrial structure, Figure 4 can be seen on the digital economy after the imposition of shocks to the impact of its own impact at the beginning of the impact is greater, with the increase in the number of periods of gradual reduction, to see that the digital

economy on the level of industrial structure of the impact is not very obvious. After the impact on the level of industrial structure, the impact of the first two periods fluctuates greatly, and after two periods, the impact gradually decreases and tends to equilibrium; the impact on the digital economy is more unstable, with no obvious trend, and the change reaches a positive peak in the sixth period, and then the fluctuation is also more obvious.

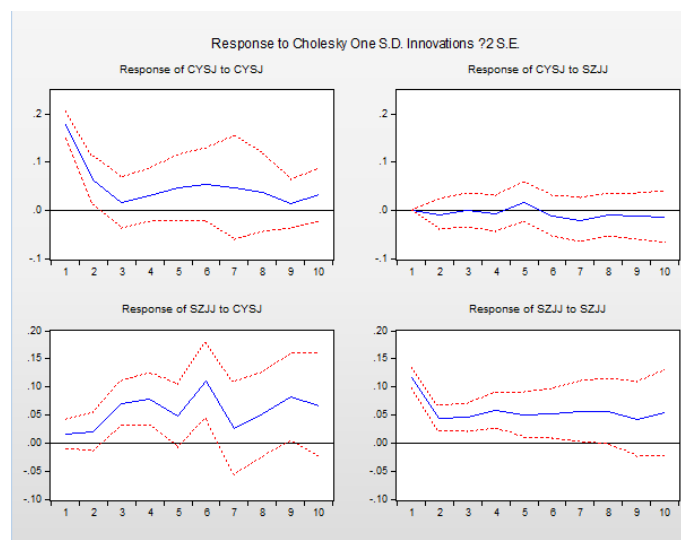


Figure 4. Impulse Response Graph

4.8. Variance decomposition

This paper through the variance decomposition of the industrial structure level, from Figure 5 can be concluded that at the beginning of the industrial structure level of the vast majority of their own explanation, with the increase in the number of periods of the digital economy can be explained by the proportion of the increase in the digital economy can eventually reach the proportion of about 20 per cent, indicating that the digital economy can explain a part of the reasons for the changes in the level of industrial structure.

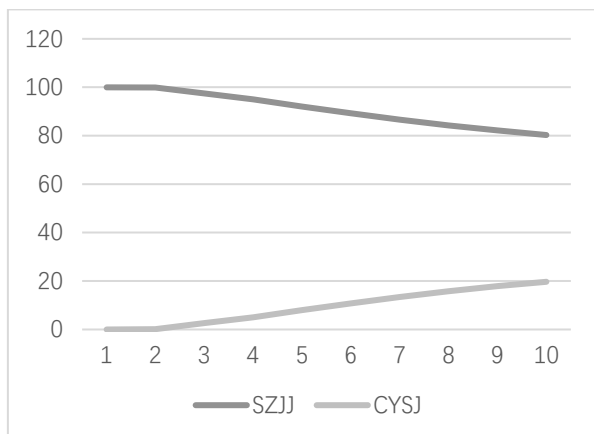


Figure 5. Variance Decomposition

5. Conclusions and Recommendations

5.1. Conclusion

This paper constructs digital economy-enabled industry high-quality development indicators from multiple dimensions, and constructs entropy weight-TOPSIS model and PVAR model to explore the internal mechanism of digital economy and industrial transformation and upgrading in 11 prefecture-level cities in Jiangxi Province, and the conclusions are as follows:

Overall, the comprehensive level of digital economy in some cities still shows an upward trend in general, although it declined in 2009-2010 and 2013-2014, while the differences in the level of digital economy development in each city are getting bigger and bigger with the development of the times as well as different policies;

The overall view of the cities in Jiangxi Province with the change of time, the level of industrial transformation and upgrading gradually improved, Nanchang industrial transformation and upgrading index level in 2012, 2013 leading, followed by Xinyu, Jiujiang, Pingxiang, Jingdezhen, Ganzhou on top, indicating that the level of industrial structure of various regions of Jiangxi Province in the dynamic changes in the level of the industry, and the industrial transformation of various regions of the policy is not the same, and some regions have introduced one after another to fit the local characteristics of the policies;

Through Granger causality test, it is found that the two are Granger causes for each other, impulse response and variance decomposition, it is found that the impact of digital economy on industrial structure upgrading is not particularly obvious, the level of industrial structure on the digital economy is unstable, in the variance decomposition, the digital economy is able to explain a part of the reasons for the transformation

and upgrading of industrial structure.

5.2. Recommendations

In response to the above conclusions, the recommendations are as follows:

1. Encourage the vigorous development of digital economy.

Strengthen the coordination and cooperation of various departments, smooth the mechanism obstacles that hinder the development of the digital economy, promote the construction and improvement of cloud computing, the Internet, the Internet of Things, intelligent terminals and other new technological infrastructure, and fully rejuvenate the growth and vitality of the emerging industries, in order to achieve the digital economy synergistically drive the transformation and upgrading of industries to provide a strong traction.

2. Accelerate the pace of industrial transformation and upgrading.

In the process of comprehensively deepening the reform, we constantly seek for new changes, promote industrial technological innovation, improve the backward production mode, shift from factor-driven to innovation-driven, explore the integration and development of emerging industries and characteristic advantageous industrial clusters, and promote the continuous improvement of the industrial structure of heightened, transformed and rationalised.

3. Stimulate the force of digital economy on industrial transformation and upgrading.

Actively and steadily promote market-oriented reforms in terms of breadth and depth, adhere to the focus of the property rights system and the market-oriented allocation of factors, realise effective incentives for property rights and the free flow of factors, give full play to the potential efficacy of the factors of the digital economy, and adopt measures according to local conditions to explore the road of industrial transformation and upgrading empowered by the digital economy with regional characteristics.

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