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Impact of Digital Economy on the Transformation and Upgrading of Industrial Structure

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Abstract: Does digital economy affect the pace and nature of industrial structure and if so, by how much? We discuss the linear impact, nonlinear characteristics and constraint mechanisms of the digital economy on industrial structure. We apply this to inter-provincial panel data from China and find that there is a remarkably promotion of digital economy on the advancement of industrial structure. Further, a heterogeneity analysis shows a sharp enhancement in the upgrading of industrial structure response to digital economy for the western region compared with the east and the central region. We then quantitatively test the threshold effect and find that there is an ascending trend in the upgrading of industrial structure just to the right of the digital economy threshold, and a positive marginal effect between the two. Finally, we allow for changes in the threshold variables and conclude that trade openness has a prominent marginal incremental effect on the rationalized and advanced industrial structure; when the proportion of fixed investment in real estate is the threshold variable, the digital economy only presents a marginal incremental effect on the rationalization of the industrial structure; when Internet development, human capital investment, and R&D input intensity are used as threshold variables, the digital economy noteworthily promotes advanced industrial structure.

Keywords: digital economy; rationalization of industrial structure; industrial structure upgrading; threshold effect

JEL Classification: O11; O14; E00

1. Introduction

The 19th National Congress of the Communist Party of China pointed out that it is necessary to accelerate the construction of a cyberpower, digital China, and a smart society, and vigorously promote the deep integration of the Internet, big data, artificial intelligence and the real economy. The digital economy represents a series of economic activities based on digital technology, with digital platforms as the main medium, and digital empowerment infrastructure as an essential support (Xu & Zhang, 2020), including digital core activities and digital application activities (Wu & Wang, 2021). The digital economy promotes the integrated development of the agricultural industry through kinetic energy conversion and technology spillovers (Chen, 2021); by promoting value creation (Jiao, 2020), blurring industrial boundaries, reducing transaction costs, improving the demand side (Li et al., 2020), and raising the position of the global value chain (He, 2020) and other aspects to drive the

transformation and upgrading of the manufacturing industry. It can accelerate the transformation and upgrading of the service industry and promote the progress of cross-border integration of the service industry (Cao & Li, 2020); continuously improve the high-quality and high-level development and development of the service industry (Ye, 2021), etc.

Scholars at home and abroad have carried out a lot of research. Appropriate industrial policies can facilitate the efficiency of industrial innovation (Peters et al., 2012), thereby further the transformation and upgrading of the industrial structure (Han et al., 2017). Trade liberalization (Amighini & Sanfilippo, 2014), large-scale high-speed rail construction (Luo et al., 2020), informatization (Ji & Sun, 2019) and Internet technology advancement (Xu & Zhou, 2019), foreign investment (Xiao et al., 2020), land finance and housing prices (Wang & Wu, 2019) and other factors are all conducive to upgrading the industrial structure. The relationship between financial scale (Wang et al., 2020) and financial openness (Bao, 2020) and the level of industrial structure is an inverted "U"-shaped nonlinear relationship. The national-level industrial transfer demonstration zone has inhibited the transformation and upgrading of the industrial structure (Chen & Zhou, 2020).

As a more advanced and sustainable economic form, digital economy is an important driving force to promote industrial restructuring and achieve sustainable and high-quality economic development. Accordingly, this paper will build a comprehensive index system of digital economy development based on China's provincial panel data and analyze the impact of digital economy on industrial structure transformation and upgrading by using panel regression model.

2. Research Assumptions

Generally speaking, only when the digital economy enhances the optimization of the industrial structure does it mean that the digital economy has played a vital role in boosting the transformation and upgrading of the industrial structure. With the rapid development of digital technology, various industries have also undergone differentiation, reorganization and integration due to its influence. New industries are being formed, and the speed of industrial transformation is accelerating. On the one hand, the digital economy has transformed traditional industries; on the other hand, the digital economy has promoted the formation and development of new industries. This brings about the adjustment of the proportion of the three industries in the national economy and the improvement of labor productivity, which in turn increases the proportion of the output value of the industries with high labor productivity and the level of industrial structure sophistication.

2.1. The Direct Impact of the Digital Economy on the Transformation and Upgrading of the Industrial Structure

The development of the digital economy stimulates the rational allocation of resources. At the beginning of the rise of the digital industry, China has put forward relatively clear industrial development goals and guidelines, thus avoiding some blind investment behaviors to a certain extent, which is favorable for the realization of the rationalizing the industrial structure. The state's supportive policies for the digital economy can also serve to make up

for the incompleteness of market information, raise the efficiency of resource utilization, and strengthen the degree of inter-industry correlation, which is propitious to the coordinated development of industries (Zuo et al., 2020). Chen and Yang (2021) believe that the digital economy is a new actuator for economic transformation, which can push forward the transfer of labor-intensive and heavy industry-based industrial structures to high-tech and environment-friendly industrial structures. This paper proposes that:

Hypothesis 1. The digital economy can enhance the industrial structure, propel the rationalization of the industrial structure, and then realize the transformation and upgrading of the industrial structure.

2.2. The Nonlinear Influence Mechanism of Digital Economy on Industrial Structure Transformation and Upgrading

Under the network externality, the information network benefit is related to the square term of the number of users, which makes the network value show the phenomenon of increasing marginal effect. With the deepening of the integration of the digital economy and traditional industries, the upfront fixed costs of enterprises have further increased, including the cost of subsidizing activities to attract new customers. Under the action of the Metcalfe's law, the marginal revenue brought by the expansion of enterprise user scale shows an increasing trend, thereby reducing the average cost of the enterprise and gradually forming economies of scale. This effect will become more pronounced with the development of the digital economy. Based on this, this paper proposes:

Hypothesis 2. The digital economy has an aggressive marginal effect on the sophistication of the industrial structure.

2.3. The Nonlinear Constraint Mechanism of the Digital Economy on the Upgrading of the Industrial Structure

In the digital economy era, the spillover effect of the digital economy on the industrial structure will be constrained by external factors such as trade, economy, and technology. The expansion of regional openness to the outside world can boost the knowledge spillover brought by the digital economy, which is active for enterprises to absorb experience and advanced technologies, but the introduction of foreign technologies, products, and resources will occupy the domestic market and weaken the spillover dividends of the digital economy. Another issue that needs attention is that although progressive manufacturing is a critical part of economic development, it may impede the transformation of the economy to service-oriented, and is detrimental to the role of the digital economy in industrial upgrading. In addition, R&D investment can furnish economic development with financial guarantee and figure out the problem of deficient innovation funds for enterprises; however, the increase in R&D investment will correspondingly crowd out digital technology capital, resulting in ungenerous financial support for the digital economy in the process of power the transformation of the industrial structure. Based on the above analysis, this paper proposes the following assumptions:

Hypothesis 3. The impact of the digital economy on the transformation and upgrading of the industrial structure will be subjected to the external environment.

3. Research Design

3.1. Model Settings

Based on the above theoretical analysis, the following model is established:

$$LN\_STU_{it} = \alpha_0 + \alpha_1 LN\_DIGECO_{it} + \alpha_2 LN\_CONTROL_{it} + X_t + X_i + \varepsilon_{it} \quad (1)$$

The explained variable LN_STU_{it} in model (1) represents the transformation and upgrading level of industrial structure, which is measured by the rationalization level of industrial structure (LN_TL_{it}) and the upgrading level of industrial structure (LN_TS_{it}) ,and the core explanatory variables LN_DIGECO_{it} represent the development level of the digital economy in the province i in the period t; $LN\_CONTROL_{it}$ is the set of other control variables affecting industrial structure x_t, x_i are the time and region dummy variables, respectively, which are used to reflect the time fixed effect and the regional fixed effect; $\varepsilon_{it}$are random disturbance terms. Model (1) are the effects of explanatory variables on the conditional expectations of the explained variables, and are susceptible to extreme influences. In order to more comprehensively reflect the conditional distribution of the explained variables, the quantile regression model (2) is further constructed to capture the influence of the explained variables in the extreme value.

$$LN\_STU_{it}(\tau) = \beta_0(\tau) + \beta_1(\tau) LN\_DIGECO_{it} + \beta_2(\tau) LN\_CONTROL_{it} + X_t + X_i + \varepsilon_{it} \quad (2)$$

Among them: τ (0<τ<1) represents the different quantiles of the conditional distribution, which are 0.1, 0.25, 0.5, 0.75, 0.90; the core coefficient reveals the marginal impact of the digital economy on the industrial structure of different quantiles.

3.2. Variable Design

Explanatory variables: measurement of the digital economy

This paper draws on the digital economy index system, which is based on the connotation of digital economy, focuses on the conditions, applications and environment of digital economy, and reflects the development level of digital economy in an all-round way (Wang, et al. 2021). The overall digital economy development level indicator system consists of 4 target layers, 9 subdivision indicators, and 30 variables. In the benchmark regression part, this paper uses the entropy method to calculate the digital economy development level as the explained variable, and it is estimated by AHP in the robustness check section.

Explained variable: level of industrial structure upgrading

The explained variable of this paper is the level of industrial structure upgrading. Measured by rationalization of industrial structure and advanced industrial structure.

First of all, the rationalization of industrial structure reflects the degree of coordinated development of various industrial sectors. This paper uses the Theil index (TL) to measure the level of rationalization of industrial structure according to (Gan et al., 2011). The specific

calculation formula is: $TL = \sum_{i=1}^{n} \frac{Y_i}{Y} ln(\frac{Y_i}{L_i} / \frac{Y}{L})$,which Y represents output value and L represents employment, i represents the industry, and n represents the number of industry sectors. The Theil Index (TL) is an inverse index. The closer its value is to 0, the closer the current industrial structure is to an equilibrium and more reasonable state. The degree of deviation of industrial structure refers to the degree of difference between the proportion of added value of each industry and the corresponding proportion of labor force. In this paper, the degree of deviation of industrial structure (E) is selected to measure the rationalization level of industrial structure as a replacement indicator for robustness testing. The specific calculation formula is: $E = \sum_{i=1}^{n} \left| \frac{Y_i/L_i}{Y/L} - 1 \right| = \sum_{i=1}^{n} \left| \frac{Y_i/Y_i}{L/L} - 1 \right|$, The larger the E value, the more the economy deviates from the equilibrium state, and the more unreasonable the industrial structure is.

Secondly, considering that the upgrading of industrial structure is dominated by modern service industry, this paper chooses the GDP ratio of tertiary industry and secondary industry to measure the advanced level of industrial structure (TS). The robustness test is carried out according to "1×the proportion of primary industry +2×the proportion of secondary industry +3×the proportion of tertiary industry". The higher the value is, the higher the level of industrial structure is.

Control Variable

The main control variables selected in this paper are: the level of economic development (pgdp). Economic development is an important driving force for the transformation and upgrading of the industrial structure. This paper uses the per capita GDP to measure; Marketization level(mark), which is measured by the ratio of non-state-owned enterprise employees to total employment; Social consumption(soc). The continuous change of consumer demand and the diversification of consumption structure can promote the adjustment of industrial structure. This article uses the proportion of social retail goods consumption to GDP to represent social consumption; Foreign investment(fdi). Foreign direct investment can bring new technology and management experience, which is conducive to improving the level of industrial development. However, if foreign businessmen tend to invest in the secondary industry, it may exacerbate the imbalance of industrial structure. This study uses foreign direct investment to represent foreign business invest.

3.3. Data Sources

This article uses data related to the transformation and upgrading of the digital economy and industrial structure in 30 provinces in China from 2013 to 2018. The data comes from the official websites of the National Bureau of Statistics and the provincial statistical bureaus, China Statistical Yearbook, China Tertiary Industry Statistical Yearbook, China Information Yearbook, China Information Industry Yearbook, China Academy of Information and Communications Technology, and industry and informatization-related research reports and published data, Statistical yearbooks of various provinces over the years, and China's digital

economy development reports over the years. Due to data availability issues, Hong Kong, Macau, Taiwan and Tibet are not included.

4. Empirical Analysis

4.1. Benchmark Regression

The panel regression of model (1) was carried out through stata16.0 to examine the specific impact of the digital economy on the transformation and upgrading of the industrial structure. When the panel regression was performed by adding time effects, it was found that the joint statistic F for the time effect regression was very insignificant. Therefore, a panel model with individual effects was selected to continue the regression. In order to increase the rigor of the model and improve the credibility of the model, other control variables for the transformation and upgrading of the industrial structure are gradually added for regression.

Table 1. Benchmark regression results

VARIABLE	LN_TL			LN_TS		
	(1) OLS	(2) FE	(3) GMM	(4) OLS	(5) FE	(6) GMM
LN_GIGECO	-2.294***	-0.350***	-0.0475**	1.793***	0.595***	0.215***
	(0.624)	(0.106)	(0.012)	(0.265)	(0.145)	(0.0686)
L. LN_TS			0.828***			
			(0.0320)			
L. LN_TL						1.055***
						(0.0371)
AR (1)			-2.0176			-2.6629
			[0.0436]			[0.0077]
AR (2)			-0.66572			-1.8763
			[0.5056]			[0.0606]
_CONS	3.295***	2.880***	0.547*	0.848***	0.619**	0.0159
	(0.150)	(0.0877)	(0.294)	(0.190)	(0.234)	(0.107)
CONTROL VARIABLES	YES	YES	YES	YES	YES	YES
INDIVIDUAL EFFECT	NO	YES	NO	NO	YES	NO
N	180	180	150	180	180	150
R^2	0.353	0.149		0.795	0.733	

Note: (1) *, **, *** indicate significance at the statistical level of1%, 5%, and 10%, respectively; (2) the robust standard errors are in parentheses; (3) P-values are in square brackets; (4) Due to space limitations, this paper does not report the regression results of relevant control variables. The same below.

It can be seen from Table 1 that whether or not the OLS, fixed-effects model or GMM model is used, the digital economy as an explanatory variable has prominently propel the level of rationalization and upgrading of the industrial structure, and the level of industrial structure in the past will affect the current period.

4.2. Quantile Regression Results

The panel fixed effect model reflects the impact of the digital economy in the mean range. In order to describe the characteristics of extreme value regions and reduce the impact of extreme values, and to fully reflect the role of the digital economy on the transformation and upgrading of the industrial structure, the panel quantile regression method was selected as showed in model (2) to estimate the effect at different quantiles (Table 2). Columns (1) to (5)

in Table 2 represent the effect of the digital economy at the 10%, 25%, 50%, 75%, and 90% quantiles when controlling for individual effects and other control variables. The quantile regression results show that the fitting coefficients of the rationalization and advanced level of the industrial structure vary between [-5.041, -0.415], [0.917, 2.476], respectively, indicating that the digital economy has an impact on the rationalization and advanced level of the industrial structure. The change level has a significant effect at different quantiles. Although it shows an irregular "N" development tendency, the overall shows an upward trend.

Table 2. Quantile regression results

VARIABLE	QR_10	QR_25	QR_50	QR_75	QR_90
	(1)	(2)	(3)	(4)	(5)
DIGECO_TL	-0.415***	-0.780***	-0.607***	-1.055***	-5.041*
	(0.00749)	(0.00311)	(0.118)	(0.0549)	(2.831)
DIGECO_TS	1.205***	0.917***	1.806***	2.476***	2.123***
	(0.225)	(0.164)	(0.498)	(0.0686)	(0.121)
N	180	180	180	180	180

4.3. Endogenous Resolution

Endogenous problems in the model will affect the model estimation results. To address this issue, we chose to retest using the panel instrumental variables method. The number of fixed telephones per 10,000 people in 1984 (Huang, et al. 2019) and the digital economy lag by one period are used as instrumental variables. As can be seen from the fitting results of the first stage in Table 3, the fitting coefficients of the number of fixed telephones per 10,000 people and the first-order lag of the digital economy are all significantly positive, and they have passed the weak instrumental variable test, the over-identification test and the unidentifiable test. It testifies that the number of fixed telephones per 10,000 people and the first-order lag of the digital economy are desirable instrumental variables that meet both the correlation and exogenous requirements. According to the fitting results of the second stage,

Table 3. Endogenous test results

VARIABLE	LN_TL		LN_TS	
	FIRST STAGE	SECOND STAGE	FIRST STAGE	SECOND STAGE
	(1)	(2)	(3)	(4)
DIGECO		-0.5137**		1.296**
		(0.1461)		(0.569)
FIXED TELEPHONES PER 10,000 PEOPLE	0.00001***		0.0000*	
	(2.75e-06)		(6.94e-06)	
L. DIGECO	2.91e-06**		1.4801***	
	(1.40e-06)		(0.1879)	
Anderson canon. corr. LM statistic	49.779		51.611	
	[0.0000]		[0.0000]	
Cragg-Donald Wald F statistic	36.259		42.261	
Sargan statistic	0.000		0.498	
	[0.9917]		[0.4802]	
CONTROL VARIABLES	YES	YES	YES	YES
INDIVIDUAL EFFECT	YES	YES	YES	YES
N	180	180	180	180
R^2	0.4901	0.1096	0.6571	0.6771

after controlling the individual effect and other control variables, the fitting coefficients of the digital economy to the rationalization and advanced level of the industrial structure are -0.5137 and 1.296, respectively. This reveals that after using landlines per 10,000 people and the digital economy lag by one period as instrumental variables, the furthered effect of the digital economy on the industrial structure is robust.

4.4. Robustness Test

The digital economy and industrial structure are affected by many factors. In order to ensure the reliability of the analysis results, further robustness tests are required. Columns (2) and (4) in Table 4 are the regression results of the rationalization and upgrading of the replacement industrial structure, respectively, and columns (1) and (3) are the regression results of the digital economy re-estimated by the AHP, signifying that whether replacement of indicators and replacement of estimation methods, the digital economy still facilitates the rationalization and advanced level of industrial structure, manifesting that the core conclusion of this paper is stable.

Table 4. Robustness test results

VARIABLE	LN_TL		LN_TS	
	REPLACE OF DIGECO	REPLACE OF LN_TL	REPLACE OF DIGECO	REPLACE OF LN_TS
	(1)	(2)	(3)	(4)
DIGECO2	-0.0683**		0.163***	
	(0.0207)		(0.0232)	
DIGECO		-0.0445**		2.182***
		(0.0216)		(0.439)
_CONS	2.8282***	0.462***	1.730***	1.382***
	(0.0904)	(0.0604)	(0.113)	(0.144)
N	180	180	180	180
R^2	0.2105	0.439	0.712	0.656

5. Further Analysis

5.1. Heterogeneity Analysis

The industrial structure is subject to the influence of regional resource endowment, regional infrastructure and regional economic development level. Based on this, the impact of the digital economy on the transformation and upgrading of different regional industrial structures is further investigated. It can be seen from Table 5 that the digital economy has played a conspicuous role in assisting the rationalization and advanced level of the industrial structure in the eastern, central and western regions, declaring that the digital economy has a main function in promoting the transformation and upgrading of the industrial structure, and the impact shows a trend of central > western > eastern. One explanation is that with the continuous development of the economy, the industrial structure of the eastern region has a higher tendency of "service-oriented", that is, the industrial structure of the eastern region is more reasonable than that of the central and western regions, which are dominated by primary and secondary industries. Compared with the western region, the industrial development foundation of the central region is better, which can provide better element

support for the effect of the digital economy. Therefore, the effect of industrial transformation and upgrading in the central region is better than that in the western region. From the columns (3) and (7) in Table 5, it is clear that the digital economy has a boosting effect on the rationalization of the industrial structure in the northeast, but the result of the advanced industrial structure is indistinctive. The possible reason is that there is a clear gradient gap between the northeast region and the eastern region, the economic is suboptimal, the population continues to flow out. In addition, the industry is concentrated in heavy industry, resulting in an unbalanced economic structure and insufficient development of emerging industries such as electronic information and communication. At the same time, the connection between upstream and downstream industrial chains is not perfect. Therefore, digital technologies such as informatization, digitization, and intelligence can help to rationalize the structure of the three major industries, but whether the industrial structure has a service-oriented trend has not yet shown an impact at this stage.

Table 5. Heterogeneity test

VARIABLE	LN_TL				LN_TS			
	EAST	CENTRAL	NORTH EAST	WEST	EAST	CENTRAL	NORTH EAST	WEST
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DIGECO	-0.0325***	-0.0763***	-0.229*	-0.0567**	0.630***	0.825**	2.362	0.588**
	(0.0075)	(0.0101)	(0.0722)	(0.0215)	(0.134)	(0.245)	(2.454)	(0.228)
_CONS	0.273	0.530***	-0.342	0.228***	2.131***	0.453	1.687**	0.979***
	(0.167)	(0.0433)	(0.171)	(0.0553)	(0.249)	(0.316)	(0.228)	(0.153)
N	60	36	18	66	60	36	18	66
R^2	0.686	0.889	0.962	0.599	0.869	0.737	0.800	0.643

5.2. Threshold Effect Test

In order to further analyze the nonlinear dynamic characteristics of the digital economy on the transformation and upgrading of the industrial structure, according to the panel threshold model of Hansen (1999), the nonlinear impact of the digital economy on the transformation and upgrading of the industrial structure is investigated. Build the model as follows:

$$LN\_ISTU_{it} = \gamma_1 LN_DIGECO_{it} \cdot I(LN_DIGECO_{it} \le \theta_1) + \gamma_2 LN_DIGECO_{it} \cdot I(\theta_2 \ge LN_DIGECO_{it} > \theta_1) + \cdots + \gamma_{n+1} LN_DIGECO_{it} \cdot I(LN_DIGECO_{it} \le \theta_n) + \delta_1 LN_CONTROL_{it} + X_t + X_i + \varepsilon_{it} \quad (3)$$

In model (3), $\theta_1 \sim \theta_n$ are n threshold values. I（*）is an indicator function, which takes the value1 when the conditions in the parentheses are satisfied, and 0 otherwise. In addition, considering the constraint mechanism that affects the digital economy on the transformation and upgrading of the industrial structure, the following model is constructed:

$$LN\_ISTU_{it} = \gamma_1 LN\_DIGECO_{it} \cdot I(T_{it} \le \theta_1) + \gamma_2 LN\_DIGECO_{it} \cdot I(\theta_2 \ge T_{it} > \theta_1) + \cdots + \gamma_{n+1} LN\_DIGECO_{it} \cdot I(T_{it} \le \theta_n) + \delta_1 LN\_CONTROL_{it} + X_t + X_i + \varepsilon_{it} \quad (4)$$

In model (4), T_{it} represents the threshold variable. There are five threshold variables in this paper: 1) Internet development. Internet Broadband Access Port (IBAP) is a way to

communicate with the outside world through a computer. This paper chooses it as a measurement variable for Internet development. 2) Economic operation. As the main source of local fiscal revenue, real estate fixed investment is not only a fixed asset investment but also involves people's livelihood, and can be a good measure of local economic operation. Therefore, the proportion of real estate fixed asset investment in GDP (IREFA) is selected to measure the degree of local economic operation. 3) Trade liberalization. This paper chooses the proportion of total imports and exports to GDP (OPEN) to measure trade openness. (4) Technological innovation. Select R&D input (RD) to measure the level of technological innovation. 4) Human capital. College students serve as a talent pool, supplying talents from all walks of life to the society. This paper chooses the proportion of graduates (HC) to measure the level of human capital.

According to the results in Table 6, a reasonable explanation is that when the digital development reaches a certain value, rationalization of the industrial structure exceeds a certain value, so the role played by the digital economy is gradually decreasing; however, the tendency of industrial servitization is still expanding, so the influence of the digital economy on the advanced industry displays a marginal increasing effect. In summary, the impact of the digital economy on the industrial structure is non-linear and forward shock, but it has a marginal decreasing effect on the rationalization and a marginal increasing effect on the advanced industrial structure.

Under the heterogeneous restriction of Internet development, economic operation, trade opening, technological innovation, human capital and other factors, the digital economy also has nonlinear characteristics for the upgrading of China's industrial structure. When Internet development, human capital investment, and R&D investment are used as threshold variables, and with the reinforcement of the above variables, the digital economy presents a marginal declining effect on the rationalization of the industrial structure, and a marginal

Table 6. Test of threshold effect of digital economy on industrial structure

VARIABLE		DIGECO	IBAP	HC	IREFA	OPEN	RD
		（1）	（2）	（3）	（4）	（5）	（6）
Rationalization of industrial structure	DIGECO_0	-0.558***	-0.182***	-7.949***	-0.859**	-1.559***	-4.558***
		(0.203)	(0.0347)	(1.164)	(0.434)	(0.499)	(0.802)
	DIGECO_1	-0.274**	-0.0569*	-2.061***	-4.337***	-4.273***	-1.238***
		-0.558***	-0.182***	(0.412)	(1.002)	(0.942)	(0.440)
	THRESHOLD	0.3444	2760.1	47.046	0.0735	0.1683	271
	P-VALUE	[0.0640]	[0.0000]	0.032	0.064	0.018	0.0260
Advanced industrial structure	DIGECO_0	-0.571**	0.184	0.325**	3.259***	-0.0980**	-0.117***
		(0.275)	(0.118)	(0.165)	(0.782)	(0.0435)	(0.0445)
	DIGECO_1	0.477***	0.569***	1.021***	1.806***	0.110***	0.0989***
		(0.107)	(0.104)	(0.128)	(0.265)	(0.0183)	(0.0122)
	THRESHOLD	0.591	1580.5	26.8151	0.2067	0.7968	0.0045
	P-VALUE	[0.0260]	[0.0180]	0.0920	0.0250	0.0600	0.1840

ascendant effect on the advanced industrial structure; when trade openness is used as the threshold variable, the digital economy has a marginal expanding effect on the rationalization and upgrading of the industrial structure; when the proportion of fixed investment in real

estate is used as the threshold variable, the digital economy has a marginal increasing effect on industrial rationalization, and a diminishing impact on the advancement of industrial structure.

6. Conclusions

Based on the theory that the digital economy actuates the transformation and upgrading of China's industrial structure, this paper comprehensively discusses the linear impact, nonlinear characteristics and constraint mechanisms of the digital economy impelling the transformation and upgrading of China's industrial structure by using the inter-provincial panel data from 2013 to 2018. The following main conclusions are drawn: First, the digital economy can potently promote the sophistication of China's industrial structure, and there is regional heterogeneity. The digital economy can conspicuously motivate the rationalization and upgrading of the industrial structure in the eastern, central and western regions, and the effect is the most impressive for the western region. For the Northeast, it only affects the rationalization of the industrial structure, and the effect of the advanced industrial structure is inapparent. Second, the digital economy has a nonlinear dynamic impact on the transformation and upgrading of the industrial structure, and with the improvement of the level of the digital economy, there is a marginal decreasing effect on the rationalization of the industrial structure, and a marginal increasing effect on the advanced industrial structure. Third, the impact of the digital economy on the upgrading of the industrial structure will be constrained by Internet development, economic operation, trade opening, technological innovation, and human capital. When Internet development, human capital investment, and R&D investment are used as the threshold variables, the digital economy shows the law of diminishing marginal effects for the rationalization of industrial structure, and the law of increasing marginal effects for the advanced industrial structure; when trade opening is the threshold variable, the digital economy reveals the law of increasing marginal effect for both the rationalization and upgrading of the industrial structure; when the proportion of fixed investment in real estate is used as the threshold variable, the digital economy demonstrates the law of increasing marginal effect for industrial rationalization, and the law of decreasing marginal effect for the advanced industrial structure. Based on the above conclusions, we should continue to implement the national Big data strategy, consolidate the digital technology application for the transformation and upgrading of industrial structure in the dividends of advantage, increase the economic impact on the transformation and upgrading of industrial structure of the digital differential effect, meanwhile, other factors should be fully aware of the external effect on digital economy in the transformation and upgrading of industrial structure.

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