

Digital Economy, Innovation Environment and Industrial Upgrading: Based on the Adjustment Effect and Threshold Model

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Abstract. Based on the panel data of 30 provinces in China from 2013 to 2020, we construct an adjustment effect model and a threshold model with residents' consumption demand, labor force quality and financial resources as the moderating variables, and residents' consumption demand as the threshold variable, in order to explore the influence process of digital economy on industrial upgrading. The empirical results show that: (1) The development level of digital economy has a significantly positive impact on the rationalization and advancement of industrial structure; (2) Residents' consumption demand, labor force quality and financial resources all play a significant positive adjustment role in the digital economy-empowered industrial upgrading; (3) There exists a threshold effect in the digital economy-empowered industrial upgrading, i.e., when the residents' consumption demand is between the two thresholds, the digital economy-empowered industrial structure rationalization is significantly promoted; when residents' consumption demand crosses the first threshold, the digital economy-empowered industrial structure advancement is remarkably enhanced.

Keywords: Digital Economy; Innovation Environment; Industrial Upgrading; Adjustment Effect; Threshold Return.

1. Introduction

General Secretary Xi Jinping has sent a congratulatory letter to the 2019 China International Digital Economy Expo, expressing that China upholds the new development concept of innovation, coordination, green, openness and sharing, and is actively promoting the dual-wheel drive of digital industrialization and industrial digitization to guide the deep integration of the digital economy and the real economy. However, as China's traditional economic growth model stalls, environmental degradation and other problems continue to emerge, the transformation and upgrading of industrial greening is imminent, so the new round of digital technology revolution is of great significance to achieve industrial upgrading.

This paper proposes the following three innovative points based on the previous study: Firstly, this paper focuses on the influence process of digital economy on industrial upgrading, assuming that the influence mechanism contains the adjustment effect and threshold effect, so as to reveal the role of digital economy in empowering industrial upgrading. Secondly, this paper selects data from 2013-2020 of each province which could connect the existing literature in terms of years and presents the latest achievements. Thirdly, the digital economy and industrial upgrading are integrated into the same analytical framework with residents' consumption demand, labor force quality and financial resources, so as to explore the adjustment effects to enrich the related studies.

2. Theoretical Analysis and Hypothesis

2.1 Direct Effects of Digital Economy on Industrial Upgrading

The digital economy empowers industrial upgrading: Since that digital Internet technology could integrate and utilize external innovation resources, share information in a timely manner, and optimize the allocation of production factors required for industrial transformation and upgrading. The positive externality, scale effect and other features of the digital economy could provide

convenience for precise matching, aggregation and application of production factors. Furthermore, the high penetration and synergy features enhance the matching and production efficiency [1].

Hypothesis H1: The level of digital economy development positively affects the degree of industrial upgrading

2.2 Adjustment Effects of Residents' Consumption Demand

Fu Jiarong (1997) [2] has proposed that changes in consumer demand fundamentally cause changes in industrial structure; Hou Zhiyang and Dai Shuangxing (2001)[3] also have argued that residents' consumer demand as the fundamental driving force dominates the upgrading of industrial structure. From the micro perspective, consumption demand plays a significant role in guiding production and product structure. From the macro perspective, through market conduction, consumption structure and industrial structure and their internal interactions guide the adjustment and upgrading of industrial structure.

Hypothesis H2: Residents' consumption demand plays a positive moderating role

2.3 Adjustment Effects of Labor Quality

Industrial upgrading empowered by digital economy needs to rely on technology support, and more importantly, it needs to rely on high-end talents to realize the deep integration of digital economy and traditional industries. High-end talents are the carriers of technology and scientific research achievements, and as the mainstay of R&D, they play a crucial role in industrial transformation and upgrading. By breaking technological constraints, it could achieve the optimized allocation of resources through R&D innovation and other ways [4].

Hypothesis H3: Labor force quality plays a positive adjustment role

2.4 Adjustment Effects of Financial Resources

At present, industries face problems in the process of technology-intensive upgrading, like R&D innovation difficulties and high cost; meanwhile, good financial resources and capital integration are indispensable[5]. On the other hand, the interactivity of data and information are closely linked to individuals in economic and social development, which makes macroeconomics more systematic[6]. Furthermore, the shortcomings of traditional financial environment such as "mismatching", "low efficiency and high cost" have been improved after digital finance make progress. The need for R&D innovation and flexible competition in industrial upgrading could also be effectively matched by the digital financial environment [7].

Hypothesis H4: Financial resources play a positive adjustment role

3. Variable Descriptions and Model Constructions

3.1 Variable Descriptions

The Selection of Explained Variables. Gan Chunhui et al. (2011) [8] divided the degree of industrial upgrading into two dimensions to measure the industrial structure. The New Theil index is used to measure the rationalization of industrial structure, and to reflect the degree of inter-industry coordination and quality of aggregation.

$$tl_{it} = \sum_{i=1}^n \left(\frac{Y_i}{Y} \right) \ln \left(\frac{Y_i}{L_i} / \frac{Y}{L} \right) \quad (1)$$

In the equation, tl represents the New Theil Index, and i stands for industry; while Y denotes industrial GDP, and L means the employed population in this industry. In order to make the rationalization and advancement of industrial structure change in the same direction, this paper adopts the inverse of the New Theil index as the measure of industrial structure rationalization.

The industrial structure advancement mainly refers to the increase of technology intensification, and therefore, this paper selects the ratio of tertiary industry output value to secondary industry output value in each province as the measurement index.

2.Selection of Explanatory Variables. In this paper, the digital economy evaluation index system is constructed from four dimensions (Ge Heping & Wu Fuxiang, 2021; Cai Yanze, Gong Xinshu & Jin Mei, 2021) [10-11].

Table 1. Digital Economy Evaluation Index System

1st-level Indicator	2nd-level Indicator	Proxy Indicator	Weight	Properties
Development Environment	Digital Infrastructure	Cell Phone Base Station Density (PCs/km ²)	0.05	+
		Internet Broadband Port Density (10,000 PCs/km ²)	0.05	+
	Innovation-driven Development	Investment Intensity of R&D Expenditure (%)	0.05	+
		Proportion of Financial Investment in Science and Technology (%)	0.05	+
Digital Industrialization	Information Transmission	Cell Phone Popularization Rate (%)	0.075	+
		Number of Mobile Internet Users as a Percentage (%)	0.075	+
	Technology Application	Telecommunications Business Per Capita (10,000 RMB/person)	0.075	+
		Software Business Income (100,000,000 RMB)	0.075	+
Industry Digitization	Intelligent Manufacturing	Number of Computers Used per 100 People in the Enterprise (PCs)	0.075	+
		Proportion of Enterprises with E-commerce Transaction Activities (%)	0.075	+
	Digital Life	E-commerce Sales (100,000,000 RMB)	0.075	+
		Online Sales (100,000,000 RMB)	0.075	+
Digital Governance	Digitized Development of Enterprises	Percentage of Total Output Value of Telecom Industry (%)	0.1	+
		Percentage of Employment Population in Telecom Industry (%)	0.1	+

In this paper, the data are standardized using 2013 as the base period.

$$X_{it} = \frac{V_{it} - V_{\min}}{V_{\max} - V_{\min}} \times 6 + 1 \quad (2)$$

i represents province, and t stands for year, while V_{max} and V_{min} denote the maximum and minimum values of the original data in the base period, respectively.

In this paper, 20% weight is given to the development environment, because it is the foundation of digital economy development; 30% weight is given to digital industrialization and industrial digitization, respectively, because they are the core of digital economy; and 20% weight is given to digital governance, because it connects the decision-making and application layers (Ge Heping & Wu Fuxiang, 2021; Cai Yanze, Gong Xinshu, & Jin Mei, 2021) [10- 11]. The level of digital economy development can be calculated with a linear weighting method.

3.Selection of Adjustment Variables. The logarithm of the ratio of the number of people engaged in R&D to the total population is used to represent the quality of labor force (Cai Yanze, Gong Xinshu,

& Jin Mei, 2021) [11]. Financial resources adopt the ratio of total credit scale to gross product as a proxy variable.

Table 2. Variable Definition

	Variable Name	Symbols	Quantification Method
Explained Variables	Degree of Industrial Upgrading (iud): Rationalization of Industrial Structure	tl	Inverse of New Theil Index
	Degree of Industrial Upgrading (iud): Enhancement of Industrial Structure	ts	Ratio of Tertiary Industry Output Value to Secondary Industry Output Value
Explanatory Variables	Level of Digital Economy Development	dig	Linear Weighting of Development Environment, Digital Industrialization, Industry Digitization, Digitized Governance
Adjustment Variables	Residents' Consumption Demand	cd	Residents Consumption Spending / Regional GDP
	Labor Force Quality	lab	Logarithm of Ratio of the Population Engaged in R&D to the Total Population
	Financial Resources	fin	Total Credit Scale / Total Output Value
	Government Expenditure Scale	gov	Government Consumption Expenditure / Final Consumption Expenditure
Control Variables	Foreign Investment	fdi	Foreign Direct Investment / Regional GDP
	R&D Expenditure	rde	R&D Expenditure / Regional GDP
	Level of Economic Development	ed	Logarithm of GDP Per Capita

3.2 Model Construction

The baseline regression model (3) is constructed to explore the effect of the level of digital economy development on the degree of industrial upgrading.

$$iud_{it} = \alpha_1 dig_{it} + \alpha_2 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (3)$$

In the equation (3), $i=1, 2, \dots, 30$ (representing each province), and $t=2013, 2014, \dots, 2020$ (standing for each year), while iud denotes the degree of industrial upgrading, and $\sum control_{it}$ denotes the control variables; ε_{it} is a random disturbance term; $Z'_i \varphi$, in the fixed effects model is C_i , and in the random effects model is $\varphi + \mu_i$; α denotes the regression coefficient.

$$iud_{it} = \beta_1 dig_{it} + \beta_2 cd_{it} + \beta_3 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (4)$$

$$iud_{it} = \gamma_1 dig_{it} + \gamma_2 cd_{it} + \gamma_3 dig_{it} \times cd_{it} + \gamma_4 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (5)$$

Model (4) and model (5) are used to determine the adjustment effect of residents' consumption demand.

$$iud_{it} = \delta_1 dig_{it} + \delta_2 lab_{it} + \delta_3 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (6)$$

$$iud_{it} = \xi_1 dig_{it} + \xi_2 lab_{it} + \xi_3 dig_{it} \times lab_{it} + \xi_4 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (7)$$

Model (6) and model (7) are used to determine the adjustment effect of labor force quality.

$$iud_{it} = \rho_1 dig_{it} + \rho_2 fin_{it} + \rho_3 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (8)$$

$$iud_{it} = \eta_1 dig_{it} + \eta_2 fin_{it} + \eta_3 dig_{it} \times fin_{it} + \eta_4 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (9)$$

Model (8) and model (9) are used to determine the adjustment effect of financial resources.

$$iud_{it} = \lambda_1 dig_{it} + \lambda_2 cd_{it} + \lambda_3 lab_{it} + \lambda_4 fin_{it} + \lambda_5 dig_{it} \times cd_{it} + \lambda_6 dig_{it} \times lab_{it} + \lambda_7 dig_{it} \times fin_{it} + \lambda_8 \sum control_{it} + Z'_i \varphi + \varepsilon_{it} \quad (10)$$

4. Empirical Analysis

This paper constructs a model relying on the adjustment and threshold effects, and it uses StataMP 16 to conduct an empirical analysis, so as to examine whether adjustment and threshold variables are reasonable and to test the above hypotheses.

4.1 Data Sources and Descriptive Statistics

This paper applies the panel data of 30 Chinese provinces (excluding Tibet, Hong Kong, Macao and Taiwan, the same below) from 2013 to 2020 as the initial samples, and the data are obtained from the National Bureau of Statistics, GuoTaian, and the statistical yearbooks of each province. The interpolation method is used to supplement few missing values.

Table 3. Descriptive Statistics of Variables

Variable Name	Symbol	Sample	Mean	Standard Deviation	Median	Min	Max
Industrial Structure Rationalization	tl	240	11.9396	14.0459	6.6005	1.8802	122.5598
Industrial Structure Advancement	ts	240	1.3968	0.7440	1.2212	0.6653	5.2440
Level of Digital Economy Development	dig	240	3.5242	1.7303	3.0713	1.5111	11.3949
Residents' Consumption Demand	cd	240	0.4729	0.0623	0.4730	0.3472	0.6295
Labor Force Quality	lab	240	-6.1822	0.7854	-6.3189	-7.5238	-4.1760
Financial Resources	fin	240	1.4810	0.4122	1.3959	0.7303	2.6906
Government Expenditure Scale	gov	240	0.2727	0.0566	0.2616	0.1791	0.4984
Foreign Investment	fdi	240	0.0197	0.0172	0.0183	0.0001	0.1210
R&D Expenditure	rde	240	0.0178	0.0114	0.0148	0.0045	0.0647
Level of Economic Development	ed	240	10.8696	0.1728	10.8090	10.4628	11.2040

4.2 Model Selection and Analysis of Regression Results

Model Selection. The panel data are judged to be suitable for either a fixed-effects model or a random-effects model by the Hausman test. The test results are shown in Table 4 and Table 5, and models (3)-(10) all use the fixed-effects model.

Analysis of Regression Results. In this paper, fixed-effects regressions are conducted for models (3)-(10). In Table 4, model (3) is a single regression of digital economy on industrial structure rationalization, and the coefficient is positive and statistically significant at the 1% level. Model (4) introduces residents' consumption demand as the adjustment variable based on model (3), and model (5) further introduces the interaction term between digital economy and residents' consumption demand based on model (4), and the coefficient of the interaction term is positive and statistically significant at the 1% level, indicating that residential consumption demand has a significant positive adjustment effect. Model(6) introduces the adjustment variable labor force quality on the basis of model (3), while model (7) further introduces the interaction term between digital economy and labor force quality on the basis of model (6), and the coefficient of the interaction term is significantly positive at the 5% level. Model (8) introduces financial resources on the basis of model (3), while model (9) further introduces the interaction term between digital economy and financial resources on the basis of model (8), and the coefficient of the interaction term is significantly positive at the 1% level. The above results are still significant in model (10).

Table 4. Regression of Digital Economy on Industrial Structure Rationalization

	(3)	(4)	(5)	(6)	(7)
dig	4.7893*** (0.8153)	4.5317*** (0.8153)	-0.5690*** (2.8366)	4.8742*** (0.8136)	9.2071*** (2.1275)
cd		45.5652** (20.1521)	-4.9996** (27.4768)		
dig×cd			31.5498*** (5.7087)		
lab				7.2187* (4.3857)	4.9955* (4.4609)
dig×lab					0.9063** (0.4118)
fin					
dig×fin					
gov	29.2418 (20.2978)	38.4592* (20.5065)	26.1674 (19.2942)	26.4660 (20.2839)	29.9171 (20.1566)
fdi	-44.9281 (44.5079)	-39.9306 (44.1234)	-59.5178 (41.3903)	-35.8381 (44.6662)	-14.6592 (45.2858)
rde	156.5297 (272.7388)	192.355 (270.5081)	287.9157 (253.4108)	-74.8686 (338.097)	-369.2406 (346.4062)
ed	-13.7552*** (5.0682)	-15.0806*** (5.0523)	-13.7413*** (4.7281)	-16.1235*** (5.2483)	-8.6301 (6.2153)
_cons	134.6964** (53.6547)	125.2134** (53.2898)	166.0657*** (50.3509)	211.2536*** (70.8408)	121.8742 (81.0875)
Hausman Test	0.0001	0.0000	0.0000	0.0102	0.0012
	(8)	(9)	(10)		
dig	4.4695*** (0.7979)	-1.6016 (2.1019)	4.8393* (3.1565)		
cd			-112.4659*** (32.8234)		
dig×cd			52.1135*** (6.6045)		
lab			-3.5266* (4.1130)		
dig×lab			2.9976*** (0.4841)		
fin	12.3771*** (3.4635)	5.5898* (4.0330)	4.7254* (4.9664)		
dig×fin		2.7130*** (0.8719)	0.6332* (0.8870)		
gov	43.6605** (20.1472)	42.3920** (19.7359)	37.03** (17.3512)		
fdi	-25.2800 (43.6304)	0.7186 (43.5400)	4.1968 (38.7096)		
rde	135.9682 (265.2931)	193.9919 (260.4909)	-467.7281 (298.6226)		
ed	-19.2716*** (5.1648)	-9.6152 (5.9345)	6.2903 (6.0771)		
_cons	173.5001*** (53.2955)	83.7731 (59.6331)	-36.6679 (73.6851)		
Hausman Test	0.0003	0.0009	0.0494		

Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively.

Table 5. Regression of Digital Economy on Industrial Structure Advancement

	(3)	(4)	(5)	(6)	(7)
dig	0.0444*** (0.0162)	0.0297** (0.0147)	0.1047* (0.0546)	0.0416*** (0.0160)	0.1698*** (0.0412)
cd		2.5974*** (0.3635)	3.1464*** (0.5290)		
dig×cd			0.1567* (0.1099)		
lab				-0.2397*** (0.0863)	-0.3054*** (0.0865)
dig×lab					0.0268*** (0.0080)
fin					
dig×fin					
gov	-2.0602*** (0.4044)	-1.5348*** (0.3699)	-1.4738*** (0.3715)	-1.9681*** (0.3993)	-1.8659*** (0.3908)
fdi	-2.4240*** (0.8867)	-2.1391*** (0.7959)	-2.0419** (0.7969)	-2.7258*** (0.8793)	-2.0991** (0.8780)
rde	4.8812(5.4336)	6.9234(4.8797)	6.4488(4.8788)	15.8840** (6.6557)	10.1328(6.7160)
ed	0.4745*** (0.1010)	0.3990*** (0.0911)	0.3923*** (0.0910)	0.5531*** (0.1033)	0.7749*** (0.1205)
_cons	-3.3948*** (1.0689)	-3.9354*** (0.9613)	-4.1383*** (0.9694)	-5.9366*** (1.3946)	-8.5813*** (1.5721)
Hausman Test	0.0000	0.0000	0.0000	0.0000	0.0000
	(8)	(9)	(10)		
dig	0.0330** (0.0148)	-0.0262 (0.0395)	0.1623*** (0.0626)		
cd			1.6634** (0.6506)		
dig×cd			0.2056* (0.1309)		
lab			-0.2746*** (0.0815)		
dig×lab			0.0461*** (0.0096)		
fin	0.4416*** (0.0641)	0.3754*** (0.0759)	0.1587* (0.0984)		
dig×fin		0.0265* (0.0164)	0.0067* (0.0176)		
gov	-1.5457*** (0.3726)	-1.5581*** (0.3712)	-1.2521*** (0.3439)		
fdi	-1.7230** (0.8069)	-1.4695* (0.8190)	-1.2563 (0.7673)		
rde	4.1476 (4.9064)	4.7133 (4.8999)	4.5361 (5.9189)		
ed	0.2777*** (0.0955)	0.3718*** (0.1116)	0.7607*** (0.1205)		
_cons	-2.0103** (0.9857)	-2.8851** (1.1217)	-9.2149*** (1.4605)		
Hausman Test	0.0000	0.0000	0.0000		

Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively.

In Table 5, model (3) is a single regression of the digital economy on industrial structure advancement, with a positive and statistically significant coefficient at the 1% level. Similarly, the adjustment variable residents' consumption demand is introduced in model (4), while the interaction term between digital economy and residential consumption demand is introduced in model (5), and the coefficient of the interaction term is 0.1567, which is significant at the 10% level. Model (6) introduces labor force quality, while model (7) introduces the interaction term between digital economy and labor quality, and the coefficient of the interaction term is 0.0268, which is significant at the 1% level. Financial resources are introduced in model (8), while the interaction term between digital economy and financial resources is introduced in model (9), and the coefficient of the interaction term is 0.0265, which is statistically significant at the 10% level. The above results indicate that consumption demand, labor force quality and financial resources have a significant positive adjustment effect between digital economy and industrial structure advancement.

The regression results of model (3) in Table 4 and Table 5 showcase that, the digital economy positively empowers industrial upgrading and is statistically significant at the 1% level, i.e., hypothesis H1 holds true. Model (4) and model (5) showcase that hypothesis H2 holds true. Models (6) and (7) showcase that hypothesis H3 is valid. Model (8) and model (9) showcase that hypothesis H4 is valid.

4.3 Robustness Testing

In this paper, the median size of government spending is used as the basis for dividing the samples into two groups, conducting fixed effects regressions separately, and comparing the regression coefficients and significance for robustness testing.

Table 6. Sub-sample Regressions Grouped by Government Expenditure Scale

	tl		ts	
	Government Expenditure Scale is Low	Government Expenditure Scale is High	Government Expenditure Scale is Low	Government Expenditure Scale is High
dig	2.7214*(3.8574)	2.4127*(2.0808)	0.0893*(0.0727)	0.4955*** (0.1188)
cd	13.9677*(44.3188)	-28.3554(20.4858)	2.0728** (0.8348)	1.1378(1.1698)
dig×cd	35.1101*** (7.6540)	18.0899*** (5.3218)	0.0791* (0.1442)	0.7131** (0.3039)
lab	-0.1006(4.8911)	-4.2519* (2.3414)	-0.0941(0.0921)	-0.3130** (0.1337)
dig×lab	3.4645*** (0.5942)	0.7351** (0.3036)	0.0249** (0.0112)	0.0957*** (0.0173)
fin	-29.2972*** (9.2220)	6.9573*** (2.4366)	0.1972(0.1737)	0.4224*** (0.1391)
dig×fin	4.1653*** (1.5920)	2.6582*** (0.5924)	0.0156* (0.0300)	0.1044*** (0.0338)
_cons	-171.4601** (78.1573)	24.6278 (44.5966)	-9.9899*** (1.4722)	-5.9648** (2.5467)
N	120	120	120	120
Control Variables	Yes	Yes	Yes	Yes

Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively.

The sub-sample regression results are basically consistent with Tables 4 and 5. The positive, negative and significant coefficient estimates of key variables are consistent with the previous analysis, which proves that the model is robust.

4.4 Threshold Effects

In order to investigate whether the promotion effect of residents' consumption demand, labor force quality and financial resources to strengthen the digital economy on industrial upgrading is linear, this paper uses a bootstrap self-help method to estimate the threshold value and related statistics. As shown in Table 7, for industrial structure rationalization, the single threshold effect is significant at the 5% level, and the double threshold is significant at the 1% level when residents' consumption demand is used as the threshold variable. For industrial structure advancement, the single threshold effect is significant at the 10% level, and the double threshold is insignificant when residents' consumption demand is used as the threshold variable.

Table 7. Threshold Estimates and Test Results

Variable	Threshold Type	tl						
		F Value	P Value	Critical Value			Threshold Value	Confidence Interval
				10%	5%	1%		
cd	Single Threshold	80.01	0.0467	55.155	73.807	108.961	0.535**	[0.526,0.537]
	Double Threshold	172.43	0.0000	36.049	56.857	90.977	0.537*** 0.541***	[0.537,0.541] [0.528,0.550]
Variable	Confidence Interval	ts						
		F Value	P Value	Critical Value			Threshold Value	Confidence Interval
				10%	5%	1%		
cd	Single Threshold	37.60	0.0633	32.681	44.873	57.115	0.541*	[0.537,0.550]

To explore the nonlinear relationship between digital economy and industrial upgrading, this paper sets dummy variables based on the threshold value of residential consumption demand to generate interaction terms with the digital economy.

$$tl_{it} = \mu_{it} + \alpha_1 dig_{it} \times I(cd_{it} \leq \delta_1) + \alpha_2 dig_{it} \times I(\delta_1 < cd_{it} \leq \delta_2) + \alpha_3 dig_{it} \times I(cd_{it} > \delta_2) + \alpha_4 X_{control} + \varepsilon_{it} \quad (11)$$

$$ts_{it} = \mu_{it} + \beta_1 dig_{it} \times I(cd_{it} \leq \gamma_1) + \beta_2 dig_{it} \times I(cd_{it} > \gamma_1) + \beta_3 X_{control} + \varepsilon_{it} \quad (12)$$

Table 8. Regression Results of Threshold Model

Threshold Variable	tl	ts
$dig_{it} \times I(cd_{it} \leq \delta_1)$	3.4004*** (0.5417)	
$dig_{it} \times I(\delta_1 < cd_{it} \leq \delta_2)$	12.6298*** (0.7155)	
$dig_{it} \times I(cd_{it} > \delta_2)$	3.7044*** (0.6910)	
$dig_{it} \times I(cd_{it} \leq \gamma_1)$		0.0430*** (0.0151)
$dig_{it} \times I(cd_{it} > \gamma_1)$		0.1143*** (0.0194)
Control Variables	Yes	Yes
_cons	75.6898** (35.3957)	-3.3775*** (0.9940)

Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively.

Regarding the adjustment effect of consumption demand in the digital economy affecting industrial structure rationalization, the estimated coefficient is small when residents' consumption demand is below the threshold value of 0.5373 or above the threshold value of 0.5413; and the role of residents' consumption demand in promoting the rationalization of industrial structure is significantly enhanced when it is between the two thresholds. Regarding the adjustment effect of consumption demand in the digital economy affecting industrial structure advancement, the estimated coefficient is small when the residents' consumption demand is below the threshold value of 0.5413; and when it crosses the threshold value, the role of residents' consumption demand in promoting the advancement of industrial structure is significantly promoted. From the above analysis, it can be seen that there is a threshold effect of residents' consumption demand on both rationalization and advancement of digital economy-empowered industrial structures.

5. Conclusions

Focusing on the impact of digital economy on industrial upgrading, the empirical results are shown as follows:

Firstly, the development level of digital economy has a significant positive impact on the rationalization and advancement industrial structure, i.e., digital economy could empower industrial upgrading. Secondly, residents' consumption demand, labor force quality and financial resources all play a significant positive adjustment role in the digital economy-empowered industrial upgrading. Thirdly, there is a threshold effect for the digital economy to empower industrial upgrading. The role of the digital economy in rationalizing the industrial structure is significantly enhanced when the consumption demand of residents is between the two thresholds; the role of the digital economy in enhancing the industrial structure is significantly enhanced when the consumer demand of residents crosses the first threshold.

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