Empirical Analysis of Digital Economy Affecting Industrial Chain Modernisation Based on Panel Regression Model and Threshold Effect Model

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Abstract. This study employs panel data from 2015-2020 to construct a panel regression model as well as a threshold effect model in order to examine the impact of the burgeoning digital economy on the modernization of the industrial chain in China. The results of the study show that the modernisation of the chain is positively influenced by the digital economy, with a nonlinear increasing trend. However, Once the development of the digital economy reaches a threshold, its catalytic effect on the modernization of the industrial chain slightly decreases. This research provides new insights for the exploration of China's industrial chain modernization and offers a solid theoretical foundation and empirical support for studying the impact of the digital economy on the modernization of the industrial chain.

Keywords: Digital Economy, Industrial Chain Modernization, Threshold Effect Model, Panel Regression Model.

1 Inroduction

The rapid development of the digital economy has provided new development ideas for upgrading the industrial chain in the context of the technological revolution. Industry chain in China currently faces issues of instability, weakness, and insecurity, necessitating the establishment of a modern industrial system. The relationship between the digital economy and the industrial chain is increasingly evident. Firstly, the digital field is evolving towards cross-border integration, platformization, and ecological development [1]. Secondly, digital technology can expand the organisation and division of labour within the industrial chain and drive the industrial transformation of the real economy [2]. Thirdly, the digital economy gradually enhances to improve the strength of the industrial chain [3]. Fourthly, the digital economy is conducive to industry chain integration [4]. Finally, the industrial Internet promotes the upgrading of the industrial chain and promotes the harmonious development between the industrial chains [5].

The digital economy extends throughout the entire industrial chain, facilitating adaptable production, consolidated sales, and intelligent supply. This advancement

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allows the industrial chain to enhance its structure, promote sustainability, and increase efficiency. Nevertheless, it also presents the possibility of a digital divide and data breaches, which can jeopardize the security of the industrial chain. Therefore, studying its impact on the industrial chain is of utmost importance. Previous research on the digital economy and industry chain modernization has primarily focused on theoretical aspects. This paper aims to establish an econometric model to empirically analyze the influence of the digital economy on industry chain modernization.

2 Theoretical Analysis and Research Hypothesis

Firstly, the digital economy accelerates the movement of technology between industrial chains and promotes the integration of industrial chains and innovation chains. Secondly, by digitizing, modularizing, and intelligentizing the industrial chain system, the digital economy can dramatically reduce its reliance on the natural environment and traditional infrastructure, better meet security needs, and improve the security and controllability of the chain. Lastly, the digital economy facilitates the flow of information, labor, and capital between regions and spaces, and combined with its natural network effects and economies of scale, it will improve the efficiency of energy resources utilisation in the industry chain. This article proposes the hypothesis:

H1. The digital economy actively promotes the modernization of the industrial chain

Han Xiaofeng et al. [6] found that the innovation spillover of network technology has non-linear characteristics. When the digital economy reaches a certain threshold of development, it is prone to form information barriers, and the marginal cost of information collection, processing, and analysis for upstream and downstream enterprises in the industrial chain will increase, resulting in a slight decrease in the level of industrial chain modernization. Thus, the following hypotheses were formulated in this study:

H2. Digital economy non-linearity for chain modernisation

3 Empirical Analysis

3.1 Variable Measures

Core Explanatory Variables.

Referring to the practice of Mao Bing [7], this paper takes the connotation and characteristics of industrial chain modernisation as the entry point, establishes the industrial chain modernisation evaluation index system, as shown in Table 1, and finally obtains the modernisation index of industrial chain (MIC) based on the assignment of the index weights of the spatio-temporal polar entropy weighting method.

Table 1. Indicator system for the modernisation of the industrial chain.

Primary indicators	Secondary indicators	Tertiary indicators
Modernisation of industrial structure	Productivity	Ratio of total labour productivity in the reporting period to total labour productivity in the base period
	Inter-industry development speed	Ratio of industrial value added to total industrial value added
	Inter-industry Labour Productivity Difference	Labour productivity by industrial sector
Modernisation of industrial synergies	Engel's coefficient for urban and rural areas	Ratio of rural industrial productivity to urban industrial productivity
	Synchronisation of income growth and economic growth	Income growth of each industry as a share of GDP
Modernisation of industrial integration	Technological Integration Capability	Number of patents filed in each industry
	Market integration capacity	Main business income of each industry
Modernisation of industrial innovation	Industrial innovation environment	Number of new industrial projects
		Number of completed or invested projects
		Total Fixed Assets of New Industries
	Industrial Innovation Technology R&D	Expenditure on R&D
		R&D investment in personnel activities
	Industrial Innovation Technology Absorption	Expenditure on technological transformation
		Expenditure on technology introduction
		Expenditure on Purchase of Foreign Technology
	Industrial Innovation Output	Gross output value of products in new industries
		Sales volume of products in new industries

Explained Variables.

The index system in Table 2 was established based on the studies of Liu Jun et al [8], Huang Hui-Qun et al [9] and Zhao Tao et al [10]. It is processed using principal component analysis to derive the digital economy development index.

Table 2. Indicator system for the digital economy development.

Target Layer	Primary Indicators	Secondary Indicators
Digital Economy Development	Internet penetration	Number of Internet users per 100 people
	Number of employees in Internet-related industries	Percentage of employees in computer services and software
	Output of Internet-related industries	Total telecommunication services per capita
	Number of mobile Internet users	Number of mobile phone users per 100 people
	Developments in digital financial inclusion	China's Digital Inclusive Finance Index

Control Variables.

To ensure an accurate estimation of whether the digital economy impacts on the modernisation of the industrial chain, control variables were added to this empirical test. These variables are as follows: (1) Government intervention degree (Gf), represented by the proportion of the government's annual general budgetary expenditures to the region's nominal GDP. (2) Openness to the outside world (Ow), expressed as the logarithm of the ratio of total regional imports and exports to regional GDP. (3) Economic Development Index (Edl), measured as the logarithm of the real per capita GDP of each region.

3.2 Model Setting

In order to test that the digital economy positively and non-linearly affects the modernisation of the industrial chain, a panel regression model and a threshold effect model were developed.

Baseline Regression Model.

The following econometric model has been developed in order to study the impact of the digital economy on the modernisation of the industrial chain.

$$MIC_{it} = a_0 + a_1 DE_{it} + a_2 Control_{it} + \varepsilon_{it} \quad (1)$$

Model (1) includes variables such as modernisation of the industry chain (MIC_{it}), the level of digital economy (DE_{it}), other control variables affecting the industry chain ($Control_{it}$), and the random error term (ε_{it}). The intercept term (a0), correlation coefficient of digital economy (a1), and correlation coefficient of control variables (a2) indicate the size and direction of their influence on the modernization of the industrial chain.

Threshold Effect Model.

Using the panel threshold effects model proposed by Hansen (1999), test whether the digital economy nonlinearly affects chain modernization, and further sets up the empirical model of threshold effect on the basis of model (1):

$$MIC_{it} = a_0 + a_1 DE_{it} \cdot I(DE_{it} \le \gamma_1) + a_2 DE_{it} \cdot I(\gamma_1 < DE_{it} \le \gamma_2) + \cdots + a_n DE_{it} \cdot I(DE_{it} > \gamma_n) + \theta Control_{it} + \varepsilon_{it} \quad (2)$$

Model (2) includes a threshold variable (DE_{it}), a schematic function (I(·)), and n threshold variables (γ1, γ2, …γn). The correlation coefficients (a1, a2, ... an+1) represents the impact of the digital economy on the modernisation of the industrial chain under different threshold intervals, and θ represents the correlation coefficient of the control variables.

4 Empirical Findings and Analysis

4.1 Analysis of the Results of the Baseline Regression

A regression analysis was conducted using Stata software to examine how the digital economy affects the modernisation of the industrial chain. The results, presented in Table 3, indicate that the digital economy development index is positively related to the degree of industry chain modernization. Adding individual and year double fixed effects to the regression model still yielded significant results, demonstrates that the development of the digital economy is conducive to the modernisation of the industrial chain. The inclusion of control variables in the analysis did not alter these findings. Overall, the study provides reliable evidence that supports Hypothesis 1, which states that digital economy promotes industrial chain modernization.

Table 3. the results of the baseline regression.

	(1)	(2)	(3)
DE	0.357***	0.775**	0.659**
	(0.056)	(0.303)	(0.325)
Gf			-0.065
			(0.125)
Edl			-0.018
			(0.016)
Ow			-0.119
			(0.088)
_cons	0.061*	0.096	1.566
	(0.036)	(0.232)	(1.102)
Fixed time	NO	YES	YES
Individual fixation	NO	YES	YES

Number of periods	6	6	6
Number of provinces	31	31	31
N	186	186	186
R^2	0.1420	0.1783	0.1958

4.2 Threshold Effect Tests

The results of the analysis using Bootstra P random sampling 300 times, shown in Table 4. The critical value of 0.6180 suggests that the promotion of industrial chain modernization is limited by the level of digital economy variables. As the degree of digital transformation improves, the positive impact on industrial chain modernization slightly weakens. Research hypothesis 2 is verified, indicating that the influence of the digital economy on industrial chain modernization is nonlinear.

Table 4. Threshold regression results.

	(1)	(2)
Threshold value	0.6180	0.6180
$DE_{it} \leq \gamma_1$	0.561***	0.691***
	(0.089)	(0.180)
$DE_{it} \geq \gamma_1$	0.516***	0.648***
	(0.080)	(0.176)
Control variables	No	Yes
Number of periods	6	6
Number of provinces	31	31
N	186	186
R^2	0.225	0.232

5 Conclusions

After establishing the benchmark regression model and the threshold effect model of the digital economy and industry chain modernisation, we conclude that the influence effect of the digital economy on the industry chain modernisation shows a positive driving effect at the national level with a non-linear upward trend, which is slightly weakened when its level reaches the threshold value of 0.6180. When formulating policies for the digital economy industry chain, attention should be paid to the breakthrough of core technologies and the construction of digital economy infrastructure. Both hardware and software should be used to promote industrial digitisation, enhance the internal capacity of the industry, increase investment in technological innovation, adapt to the needs of the modern industrial chain, and accelerate the process of digital transformation.

6 Appendix

6.1 Baseline Regression Model

A benchmark panel regression model is usually a basic model cited in the context of panel data analysis. Panel data, also known as longitudinal or mixed data, includes data from multiple units of observation at multiple points in time. This data structure allows the researcher to consider not only time-series effects but also cross-sectional heterogeneity.

The general form of a benchmark panel regression model is:

$$y_{it} = a + \beta x_{it} + u_i + \varepsilon_{it} \tag{3}$$

The benchmark panel regression model provides the researcher with a way to account for unobserved heterogeneity in panel data. This allows the researcher to obtain more accurate, biased estimates, especially when unobserved individual effects are correlated with the dependent variable.

6.2 Threshold Effect Model

Threshold Effect Models (TEMs) are used in economics and other social sciences to describe the non-linear relationship between the effect of one variable on another, where that effect changes at some threshold value. These models are particularly useful for describing situations in which the effect of one variable on another changes significantly at a particular point or region.

$$y_{it} = u_i + \beta_1' x_{it} \cdot I(q_{it} \le \gamma_1) + \beta_2' x_{it} \cdot I(\gamma_1 < q_{it} \le \gamma_2) + \cdots + \beta_n' x_{it} \cdot I(q_{it} > \gamma_n) + \varepsilon_{it} \tag{4}$$

Threshold effect models are very useful in practical research because they help researchers capture the complex non-linear relationships between certain key variables.

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References

1. Huang XH, Zhang BY. (2018) Development trend and key areas of global digital industry. Economic Research Reference, (51):53-61. DOI:10.16110/j.cnki.issn2095-3151.2018.51.006.

2. Li CF, Li DD, Zhou C. (2020) The role mechanism of digital economy driving the transformation and upgrading of manufacturing industry--an analysis based on the perspective of industrial chain. Business Research, (02):73-82. DOI:10.13902/j.cnki.syyj.2020.02.008.
3. Cheng J.(2021) Promoting industrial chain modernization with industrial internet. Innovation World Weekly, (07):24-25+6. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKibYlV5Vjs7iy_Rpms2pqwbFRRUtoUIm-HURog0FO9tzmvNRG2NfVuO-QxrrX_aIa1TWORImNgSn5&uniplatform=NZKPT.
4. Chen XD, Yang XX. (2021) Can digital economy realize the optimal strength of industrial chain? --Based on China's Input-Output Surface Plate Data, 1987-2017. Nanjing Social Science, (02):17-26. DOI : 10.15937/j.cnki.issn1001-8263.2021.02.002.
5. Zeng CH, Wang B.(2010) Industry Chain Integration, Mechanism Adjustment and Informatization Drive. Reform, (10):62-67. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKgchrJ08w1e7_IFawAif0myMHFMS1MakUVGgD31Mu1ToFucNDwoYGeTfSKreSRlbFRL10fgFApY8&uniplatform=NZKPT.
6. Han XF, Song WF, Li BX. (2019) Can the Internet become a new driving force for China's regional innovation efficiency. China Industrial Economy, (07):119-136. DOI:10.19581/j.cnki.ciejournal.2019.07.007.
7. Mao B. (2022) Construction of indicator system and comprehensive measurement of China's industrial chain modernization level. Economic system reform, (02):114-120. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C44YLTlOAiTRKibYlV5Vjs7iJTKGjg9uTdeTsOI_ra5_XdFVn8lYnxeRJPZ9Ecjkl3G0A7mjiD3Wb_PzUeA07IFK&uniplatform=NZKPT.
8. Liu J, Yang YJ, Zhang SF. (2020) Research on the Measurement and Driving Factors of China's Digital Economy. Shanghai Economic Research, (06):81-96.DOI:10.19626/j.cnki.cn31-1163/f.2020.06.008.
9. Huang QH, Yu YZ, Zhang SL. (2019) Internet development and manufacturing productivity enhancement: internal mechanism and Chinese experience. China Industrial Economy, (08):5-23.DOI:10.19581/j.cnki.ciejournal.2019.08.001.
10. Zhao T, Zhang Z, Liang SK. (2020) Digital economy, entrepreneurial activity and high-quality development - Empirical evidence from Chinese cities. Management World, 36(10):65-76.DOI:10.19744/j.cnki.11-1235/f.2020.0154.