Research on the Digital Economy Boosting the High-Quality Development of Manufacturing in Underdeveloped Areas—Taking Kaifeng City as an Example

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Abstract

This paper measures and empirically analyzes the effect of digital economy on the high quality development of manufacturing industry in Kaifeng City from the significance and problems of digital economy on the high quality development of manufacturing industry by using Super-SBM model, principal component analysis method and Tobit model. The results show that: 1) From 2012 to 2020, the manufacturing industry in Kaifeng City, except for the negative growth of electrical machinery and equipment manufacturing industry, the overall and its sub-sectors are growing in fluctuation and fluctuation. 2) The digital economy of Kaifeng City is in a period of rapid development from 2012 to 2020, leapfrogging from the low level stage in 2012 to the medium level stage in 2020. 3) The digital economy can significantly contribute to the high-quality development of manufacturing, but the strength of the boosting effect is not large. 4) Under different factor intensity, there is industry heterogeneity in the digital economy on the high-quality development of manufacturing industry, and the magnitude of its influence is capital-intensive manufacturing > labor-intensive manufacturing > technology-intensive manufacturing in order. Finally, we propose the path and countermeasures for the digital economy to promote the high-quality development of manufacturing industry in less developed regions.

Keywords

Digital Economy, Manufacturing; Tobit Model, Kaifeng City

1. Introduction

Since the reform and opening up, China's manufacturing industry has built a complete, independent and complete industrial manufacturing system with strong strength, cultivated a large number of skilled workers with high quality and low prices, improved the nation's water, electricity, transportation and other infrastructure, and absorbed the most employment in all industries in the country, but the core technology in key areas is still restricted by others. With the rapid development of the Internet, Internet of Things, cloud computing and other information technology, as well as the acceleration of the new pneumonia epidemic, the world will enter the era of digital economy, seize the historical opportunity to empower the high-quality development of the manufacturing industry with the digital economy as an opportunity to break through the core technology bottleneck of the manufacturing industry, to realize the Made in China to the Made in China "smart", to inject new momentum for China's socio-economic takeoff. In China's fourteenth five-year plan for national economic and social development and the outline of the 2035 vision, it is also clearly proposed to "give full play to the advantages of massive data and rich application scenarios, promote the deep integration of digital technology and the real economy, empower the transformation and upgrading of traditional industries, give birth to new industries and new business models, and grow new engines of economic development". According to the "China Digital Economy Development Report" of China Academy of Information and Communication Technology, China's digital economy will reach 45.5 trillion yuan in 2021, accounting for 39.8% of GDP, and the role of digital economy as a "stabilizer" and "gas pedal" of the national economy will be more prominent. The role of the digital economy as a "stabilizer" and "accelerator" of the national economy has become more prominent. According to the Ministry of Industry and Information Technology, since 2010, China's manufacturing value added has been the first in the world for 12 consecutive years, and the scale of manufacturing value added reached 31.4 trillion yuan in 2021, accounting for 27.4% of GDP, providing a strong impetus for sustainable and healthy economic and social development. However, there is a serious imbalance between the digital economy and the high-quality development of manufacturing industry in the region, and there is a gap between the east, the middle and the west in the country, and there are contradictions in the digital economy and the high-quality development of manufacturing industry in the less developed regions in the middle and the west, such as low total amount, insufficient kinetic energy, poor structure, slow efficiency, and unbalanced development between urban and rural areas. In this context, Kaifeng, as a less developed area, has also issued a variety of documents to support the development of the digital economy and promote the transformation and upgrading of the manufacturing industry. In the "Kaifeng Digital Economy Development Plan (2019-2025)" and other documents, it is proposed to increase support for the manufacturing industry, promote the

manufacturing city strategy and consolidate the cornerstone of high-quality development. Therefore, what are the connotation requirements and driving mechanism of the study to explore the digital economy to boost the high-quality development of manufacturing industry? What are the salient issues facing the high-quality development of manufacturing in less developed regions (such as Kaifeng) empowered by the digital economy? What is the impact of Kaifeng's digital economy on the high-quality development of the manufacturing industry? And what is the path to achieve high-quality development of manufacturing in less developed regions (such as Kaifeng) empowered by digital economy? These are the questions that must be answered by the research on the high-quality development of manufacturing industry in less developed regions (such as Kaifeng City) under the digital economy, moreover, it has important theoretical value and practical significance for promoting the high-quality development of China's manufacturing industry and achieving the historical leap from big to strong.

The structure of this paper is as follows, firstly, this paper compares the literature on digital economy contributing to the high quality development of manufacturing industry; secondly, this paper points out the connotation requirements, significance and problems of digital economy contributing to the high quality development of manufacturing industry; thirdly, the research area profile of this paper is described; fourthly, the selection of indicators, model construction and data sources of this paper are explained; fifthly, the results of Kaifeng manufacturing industry and digital economy are analyzed, as well as the empirical analysis and heterogeneity analysis; finally, the research conclusions of this paper are drawn and recommendations are made.

2. Literature Review

There are relatively few studies on the digital economy contributing to the high-quality development of manufacturing in less developed regions, and the references related to this study are mainly in the following two areas. The first aspect is a study on the digital economy (Wang & Chen, 2022). In recent years, 5G, blockchain, artificial intelligence, cloud computing, big data and other digital information technology are widely used in various fields of economy and society, leading to the vigorous development of digital economy. The digital economy has become the "power source" of China's economy to achieve high-quality development, and plays a pivotal role in the entire national economic system. In the search of "digital economy", there are more than 21,700 journal articles and 1654 dissertations, and the number of articles issued in the first six months of 2022 is 3418, which shows that the research on digital economy is very hot, and the literature has been studied from multiple perspectives (Xu & Zhang, 2020; Zhang, Wan, Zhang, & He, 2019; Wang, Tian, Cheng, Hao, Han, & Wang, 2018), multiple scales (Shen & Huang, 2020; Zhao, Zhang, & Liang, 2020) and multiple fields (Qian, Tao, Cao, & Cao, 2020; Wen & Chen, 2020) on digital

economy, and the study of digital economy on the high-quality development of manufacturing industry is also the focus of many scholars' research. He Wenbin explores the reconfiguration effect of digital economy on the development of China's manufacturing industry in the perspective of global value chains, arguing that digitalization is conducive to promoting China's advancement to the high-end of global value chains (He, 2021). Wang Guiduo's analysis found that the digital economy promotes the transformation and upgrading of manufacturing industry through two mediating variables of innovation capability and human capital (Wang, Cui, Zheng, & Wang, 2021); Liao Xinlin's empirical study found that the digital economy promotes the transformation and upgrading of manufacturing industry through three paths of resource allocation optimization effect, production cost reduction effect and innovation development driving effect (Liao & Yang, 2021); Zhao Xisan believed that the digital economy promotes the transformation and upgrading of manufacturing industry through breaking the bottleneck of innovation chain, improving the quality of manufacturing chain, optimizing The digital economy, according to Zhao Xisan, can accelerate China's manufacturing industry to the middle and high end of the global value chain by breaking the bottleneck of the innovation chain, improving the quality of the manufacturing chain, optimizing the efficiency of the supply chain and expanding the space of the service chain (Zhao, 2017). Song Ge believes that in the era of digital economy, the transformation and upgrading of traditional manufacturing industry can be accelerated by focusing on R&D mode, manufacturing mode, organizational form, product form, and business model (Song, 2019).

Second, the high-quality development of manufacturing. Most scholars interpret the connotation of manufacturing high-quality development from the perspectives of results, ideas and characteristics of manufacturing high-quality development, such as Yu Donghua (Yu, 2020) believes that manufacturing high-quality development refers to the whole process of manufacturing production, manufacturing and sales under the guidance of the new development concept to achieve low input of production factors, high efficiency of resource allocation, high quality of ecological environment and good economic and social benefits. He Zhengchu (He, Cao, & Wu, 2018) believes that the connotation of manufacturing quality development includes: taking the supply-side structural reform as the perspective, with high quality and efficiency as the core of development, with optimized industrial structure and innovative power development system while maintaining a certain development speed of domestic economy. It is pointed out that the high-quality development of manufacturing industry is required to focus on the development of quality and efficiency, accelerate structural adjustment, and realize the transformation of old and new dynamics while maintaining stability and smooth changes (Lv & Liu, 2019). For the construction of manufacturing high-quality development index system, it is a complex system engineering involving multiple fields and levels involving multiple fields and levels,

covering economic, environmental, social and other aspects, the views of scholars vary and there is no unified standard index construction system, Peng Shutao (Peng & Li, 2018) uses the three-factor evaluation framework of product, market and industry, Li Lin (Li & Wang, 2020) uses the efficiency and effectiveness, structural optimization, the innovation-driven and way conversion to build an indicator system, Ji Yujun (Ji & Wang, 2019) evaluates based on the five major development concepts of innovation, coordination, green, openness and sharing, Jiang Xiaoguo (Jiang, He, & Fang, 2019) indicator system covers six categories of economic efficiency, technological innovation, green development, quality branding, integration of the two cultures and high-end development, and Zhang Wenhui (Zhang & Qiao, 2018) constructs an indicator system of innovation-driven, structure optimization, speed effectiveness, factor efficiency, quality brand, integration development, green manufacturing and other seven categories of indicators, and Li Chunmei (Li, 2019) measured the high-quality development of China's manufacturing industry from eight dimensions: growth degree, efficiency degree, foreign dependence degree, innovation degree, enterprise quality, product quality, social contribution degree and environment degree. The analysis of influencing factors of manufacturing high-quality development is mostly carried out from a single perspective, such as from labor productivity (Chen, Zhang, & Yang, 2019), global value chain (Deng & Zhang, 2015), population (Zhang, 2019), spatial location (Liu & Wang, 2020), and government (Chen & Liu, 2019).

In summary, combing the literature reveals that there is still a literature gap about the digital economy on the high-quality development of manufacturing industry. Firstly, there is a lack of analysis of the significance and problems of digital economy on the high quality development of manufacturing industry in the literature; secondly, there is a lack of typical facts of high quality development of manufacturing sub-sectors at the municipal level in the literature. In view of this, this paper will fill the research gap from the following aspects: this paper takes Kaifeng, a less developed region, as an example to measure the level of high quality development of its manufacturing industry by using the Super-SBM method, estimate the level of digital economy development by using principal component analysis, analyze its spatial and temporal differences in Henan Province, and use it to empirically test the impact of digital economy on the high quality development of manufacturing industry in Kaifeng. The impact of digital economy on the high quality development of manufacturing industry is then divided into three major industry categories of labor-intensive, capital-intensive and technology-intensive according to the different degree of factor intensity, and the paths and countermeasures of digital economy in less developed regions to promote the high quality development of manufacturing industry are proposed, which can well fill the research gaps that exist in the digital economy on the high quality development of manufacturing industry at present.

3. The Connotation Requirements, Significance and Problems of Digital Economy to Promote the High-Quality Development of Manufacturing Industry

In the era of digital economy, the high-quality development of manufacturing industry needs to use the new generation of information technology means and ideas for comprehensive optimization and reform of enterprises, apply digital technology to R&D, manufacturing, sales and service, etc., digitally reengineer and integrate them, change the original production, organization and business model of manufacturing industry, break the inherent value chain distribution and competition pattern, promote the free flow of resources, and innovate and develop to form new models and new business models through enhancing the R&D and innovation ability of enterprises, improving the digital literacy of personnel, exploring online markets and other integration measures with digitalization, so as to drive the high-quality development of manufacturing industry.

In October 2017, General Secretary Xi Jinping emphasized that "accelerating the pace of building a strong manufacturing country, developing the manufacturing industry, and promoting the accelerated integration of big data and the real economy"; in March 2021, Premier Li Keqiang proposed "building the advantages of the digital economy, prompting the transformation and upgrading of the digitalization of industry and digital industrialization". Accelerating the high-quality development of the manufacturing industry is an inevitable requirement to meet the development of the digital economy, and the country has successively introduced the "Internet+" strategy, "Made in China 2025" and the national big data strategy to support the development of high-quality development of the manufacturing industry. Today, with the rapid development of digital economy, the focus of digital economy development has moved from consumption field to production field, and the digital technology has become increasingly mature. The new paradigm of development derived from digital economy can improve the production efficiency of enterprises, expand the output and operation scale, realize the reallocation of resources efficiently, accelerate the transformation of traditional industry, especially manufacturing industry, to network, digitalization, intelligence and green, and provide a favorable guarantee for the realization of manufacturing industry. It provides favorable guarantee and support for achieving high-quality development of manufacturing industry.

Combing relevant studies (Zhu & He, 2021), it can be seen that in the digital economy era, there are several shortcomings in the high-quality development of manufacturing industry in less developed regions due to the thin economic foundation and relatively insufficient factor gathering capacity, one is that the scale of digital economy is generally not large, and the ability to drive manufacturing industry is not strong; the second is that the innovation capacity of manufacturing industry is insufficient, and the road to digitalization is difficult; the

third is that smart manufacturing has just started, and the application penetration rate is relatively low; the fourth is that the digital foundation support is insufficient, and the transformation cost of manufacturing industry is high. Kaifeng City has also issued various documents to support the development of digital economy and promote the transformation and upgrading of manufacturing industry. In view of the above problems, this study tries to explore the solutions for Kaifeng, a less developed region, as an example.

4. Overview of the Study Area

Kaifeng city is located in central China, east of Henan province, adjacent to Zhengzhou in the west, and is the ancient capital of eight dynasties in China. 2021 GDP is 255.703 billion yuan, per capita GDP is 24,573 yuan, 2021 fixed asset investment in the city is 13.1% higher than the previous year, the added value of industrial manufacturing industry above the scale in the city is 8.9% higher than the previous year, in the document "Kaifeng Digital Economy Development Plan (2019-2025) The document "Kaifeng City Digital Economy Development Plan (2019-2025)" mentions that Kaifeng City has a good foundation for exploration and practice in developing digital economy and has a good development environment, especially at present, Kaifeng City is in a critical period of accelerated economic and social transformation and upgrading, which provides a broad market demand for digital economy development; in "Kaifeng City Implementation Plan for Promoting High Quality Development of Manufacturing Industry" "Kaifeng City Several Financial Support Measures for High-Quality Development of Manufacturing Industry", "Several Financial Support Measures for Cultivating and Growing Leading Industries in Kaifeng City" and other documents propose to increase the support for manufacturing industry, promote the strategy of manufacturing city, and solidify the cornerstone of high-quality development.

5. Indicator Selection, Model Construction and Data Sources

5.1. Indicator Selection

5.1.1. Explanatory Variables
In this paper, referring to Wang Rui-rong's study (Wang & Chen, 2022), this paper uses the integrated efficiency value to measure the level of high-quality development of manufacturing industry (Abbreviated as Manu), and the measurement method is estimated using the Super-SBM method. Considering the availability of data in Kaifeng city, etc., labor, capital and energy consumption are selected as input indicators in this paper, among which, the annual average number of workers (people) of manufacturing enterprises above the scale is selected as labor input indicator, the added value of manufacturing enterprises above the scale (million yuan) as capital input indicator, and energy consumption of manufacturing enterprises above the scale (tons of standard coal) as energy input indicator; the output indicator is selected as the expected output of the main

business income of manufacturing enterprises above the scale (million yuan).

5.1.2. Core Explanatory Variables

Referring to Zhao Tao's study (Zhao, Zhang, & Liang, 2020), the Internet penetration rate (the number of Internet broadband access users per 100 people), the number of Internet-related employees (the proportion of employees in the computer service and software industry to those in urban units), Internet-related output (total telecommunication services per capita), the number of mobile Internet users (the number of cell phone users per 100 people), and the development of digital inclusive finance (China Digital Inclusive Finance The indicators of five aspects (index) are then standardized and downscaled using principal component analysis, and finally the level of digital economy development in Kaifeng is derived, which is recorded as DIGE.

5.1.3. Control Variables

The control variables were selected as the level of economic development (RGDP), human capital (HUMA), government regulation (GOVR), capital investment (INVEST), financial development level (FDL), and infrastructure level (INFRA). Among them, economic development level is expressed by GDP per capita, human capital is expressed by the number of students enrolled in general higher education schools, government regulation is measured by the ratio of government fiscal expenditure to regional GDP, capital investment is expressed by social fixed asset investment, financial development level is expressed by the ratio of total deposits and loans of financial institutions to GDP, and infrastructure level is expressed by the ratio of road line miles to the total area of the upper region. Descriptive statistics of the main variables, this is shown in Table 1 below.

Table 1. Descriptive statistics of variables.

Variables	Mean	SD	Min	Max	Obs
MANU	0.602	0.263	0.100	1.000	243
LABOR	0.537	0.238	0.143	1.000	117
CAPI	0.610	0.278	0.100	1.000	63
TECH	0.734	0.269	0.172	1.000	54
DIGE	6057.637	2692.357	1233.105	11605.990	243
RGDP	38073.670	7959.099	25801.000	49166.000	243
HUMA	93598.32	7184.649	84379.000	104272.000	243
GOVR	0.163	0.015	0.141	0.185	243
FDL	1.550	0.185	1.244	1.859	243
INFRA	1.411	0.124	1.166	1.518	243
INVEST	1488.346	427.377	775.190	2092.211	243

The data in the table is calculated from Stata 14.0 software.

5.2. Model Construction

The comprehensive efficiency value of high quality development of manufacturing industry in Kaifeng is a discrete truncated value between 0 and 1. In order to avoid the case of dispersion of comprehensive efficiency value and deviation of parameter estimation, random effect panel Tobit regression model is used for analysis. The model is (Zhao, Liu, Zhu, Qin, Wang, & Miao, 2020).

$$MIC_{it} = cons + \alpha \cdot DIGE_{it} + \beta_v X_{it} + \varepsilon_{it} \tag{1}$$

where: MIC_{it} is the comprehensive efficiency value of high-quality development of manufacturing industry, i denotes Kaifeng manufacturing industry as a whole and its sub-sectors ($i = 1, 2, 3, \cdots, 27$), t denotes time ($t = 2012, 2013, 2014, \cdots, 2020$); $cons$ is a constant term; $DIGE$ is the digital economy development level; X is each control variable; α is the digital economy development level coefficient; β is the control variable coefficient; and ε_{it} is a random disturbance term.

5.3. Data Sources and Description

Considering the principles of data availability and the scientific and systematic acquisition of indicators, the research period of this paper is 2012-2020. In this paper, according to the classification standard of the National Bureau of Statistics for manufacturing industries, the manufacturing industry is divided into 31 major categories, and according to the industrial statistics of Kaifeng City, "tobacco manufacturing" is removed because there are no statistics; and because the data of some industries only exist in some years, so this paper will combine "chemical raw materials and chemical products manufacturing" and "chemical fiber manufacturing" into "chemical manufacturing" for unified accounting. Chemical raw materials and chemical products manufacturing" and "chemical fiber manufacturing" are combined into "chemical manufacturing", and "automobile manufacturing" and "railway, shipping, aerospace and aviation" are combined into a unified accounting. and "railroad, ship, aerospace and other transportation equipment manufacturing" are combined into "transportation equipment manufacturing", and "other manufacturing" "comprehensive utilization of waste resources" "metal products, machinery and equipment repair industry" unified into "other manufacturing industries" accounting, the final paper formed 26 sub-sectors. And on this basis, drawing on the research results of Yang, Ligao and other related scholars (Wang & Chen, 2022; Yang, Gong, Wang, & Chao, 2018) on the industrial classification of the three major types of manufacturing industries, the manufacturing industry is finally divided into three major types of labor-intensive (LABOR), capital-intensive (CAPI), and technology-intensive (TECH) manufacturing industries. This is shown in Table 2 below.

Table 2. Manufacturing industry classification standards for major categories.

Manufacturing Type	Sub-sectors included
Labor-intensive	Agricultural and food processing industry C13, food manufacturing C14, textile industry C17, textile and clothing industry, apparel industry C18, leather, wool, feathers and their products and footwear industry C19, wood processing and wood, bamboo, rattan, palm, grass products industry C20, furniture manufacturing C21, printing and recording media reproduction industry C23, education, industry, sports and entertainment products manufacturing C24, rubber and plastic products industry C29, non-metallic mineral products industry C30, metal products industry C33, other manufacturing C41 + 42 + 43
Capital-intensive	Wine, beverage and refined tea manufacturing C15, paper and paper products C22, petroleum, coal and other fuel processing industry C25, chemical manufacturing C26 + 28, ferrous metal smelting and rolling processing industry C31, non-ferrous metal smelting and rolling processing industry C32, general equipment manufacturing C34
Technology-intensive	Pharmaceutical manufacturing C27, special equipment manufacturing C35, transportation equipment manufacturing C36+37, electrical machinery and equipment manufacturing C38, computer, communications and other electronic equipment manufacturing C39, instrumentation manufacturing C40

The data in the table is calculated from Stata 14.0 software.

6. Analysis of Results

6.1. Analysis of Manufacturing Industry and Each Sub-Sector in Kaifeng City

As can be seen from Table 3, during the period of 2012-2020, the overall (MIC) comprehensive efficiency of manufacturing enterprises above the scale in Kaifeng City fluctuates and undulates from 0.270 in 2012 to 0.648 in 2020, with an average annual growth rate of 11.56%, and two high value points in 2014 and 2019. From the perspective of the sub-sectors, only the electrical machinery and equipment manufacturing industry (C38) showed negative growth, from 1.000 slight decline in 2012 to 0.975 in 2020, while the computer, communication and other electronic equipment manufacturing industry (C39) achieved positive growth, but the average annual growth rate was only 1.89%, the average annual growth rate of the 26 sub-sectors in the 25th place. The paper and paper products industry (C22) was the fastest growing industry in terms of average annual growth rate during the study period, being the first of the 26 segments with an

Table 3. Enterprises above the scale of manufacturing industry in Kaifeng from 2012 to 2020 Overall and its sub-sectors' comprehensive efficiency.

Industry Codes	2012	2013	2014	2015	2016	2017	2018	2019	2020
MIC	0.270	0.690	0.715	0.640	0.582	0.640	0.508	0.730	0.648
C13	0.143	0.439	0.473	0.391	0.303	0.316	0.246	0.375	0.378
C14	0.244	0.368	0.440	0.405	0.342	0.373	0.263	0.692	0.605
C15	0.279	0.731	0.654	0.599	0.375	0.546	0.620	1.000	1.000
C17	0.176	0.456	0.399	0.387	0.252	0.323	0.243	0.394	0.300
C18	0.295	0.903	0.978	0.801	0.638	0.723	0.323	0.417	0.424
C19	0.163	0.530	0.475	0.370	0.410	0.431	0.422	0.480	0.425
C20	0.196	0.504	0.382	0.420	0.458	0.597	0.639	0.333	0.339
C21	0.226	0.723	0.977	0.575	1.000	0.996	0.485	0.717	0.642
C22	0.128	0.489	0.953	1.000	0.928	0.503	0.630	0.841	0.758
C23	0.244	0.803	0.778	0.568	0.658	0.813	0.426	0.606	0.613
C24	0.170	0.511	0.518	0.493	0.643	1.000	0.412	1.000	0.559
C25	0.100	0.404	0.614	0.447	0.149	0.210	0.148	0.558	0.309
C26 + C28	0.448	1.000	1.000	1.000	0.843	0.858	0.707	1.000	0.857
C27	0.489	1.000	0.943	0.725	0.475	0.654	0.462	1.000	1.000
C29	0.205	0.586	0.546	0.446	0.315	0.375	0.372	0.649	0.520
C30	0.328	0.873	0.812	0.652	0.487	0.590	0.579	1.000	1.000
C31	0.138	0.596	0.496	0.506	0.541	0.655	0.613	1.000	0.418
C32	0.135	0.451	0.517	0.445	0.500	0.409	0.470	0.406	0.272
C33	0.222	0.680	0.665	0.711	0.504	0.664	0.258	0.573	0.730
C34	0.377	1.000	1.000	0.938	0.672	0.504	0.711	1.000	1.000
C35	0.172	0.550	0.724	0.742	0.527	0.731	0.562	0.937	0.954
C36 + 37	0.427	1.000	1.000	0.874	0.868	1.000	0.942	1.000	1.000
C38	1.000	0.941	0.888	1.000	1.000	1.000	1.000	1.000	0.975
C39	0.242	0.571	0.486	0.442	0.239	0.363	0.554	0.358	0.281
C40	0.257	0.874	0.874	0.704	1.000	1.000	0.301	0.744	0.798
C41 + 42 + 43	0.214	0.945	1.000	1.000	1.000	1.000	0.814	0.911	0.702

The data in the table is calculated from Stata 14.0 software.

average annual growth rate of 24.90%, followed by the special equipment manufacturing industry (C35) with an average annual growth rate of 23.88%, and most of the rest of the segments fluctuated between 10% and 15% in terms of average annual growth rate of overall efficiency.

6.2. Analysis of Digital Economy in Kaifeng City

From Figure 1, it can be seen that Kaifeng city has achieved rapid development of digital economy with an average annual growth rate of 21.15% since 2012 when it developed from low level stage to medium level stage in 2020. However, compared with other prefecture-level cities, the foundation of its digital economy development level is still relatively weak, from the ranking, since 2012, 17th in the ranking of 17 prefecture-level cities, rose rapidly to 6th in 2016, and then fell to 12th in 2020, failing to reach a high level of development stage, indicating that Kaifeng's digital economy needs further development, especially to pay attention to the linkage development with Zhengzhou City, which always ranks 1st in digital economy development.

6.3. Empirical Test Analysis

Random effects panel Tobit regression analysis was conducted using Stata 14.0 software, and the results are shown in Table 4. The LR test results for model (7) strongly reject the original hypothesis, indicating that there is an individual effect and that it is reasonable to use random effects panel Tobit regression with Prob > chi2 = 0.000, indicating that the model fits well.

As can be seen from Table 3, model (1) does not include any control variables and only analyzes the impact of digital economy on the high quality development of manufacturing industry in Kaifeng City, the result of which is that the level of digital economy development passes the significance test at 1% level and the coefficient is positive, indicating that digital economy development will
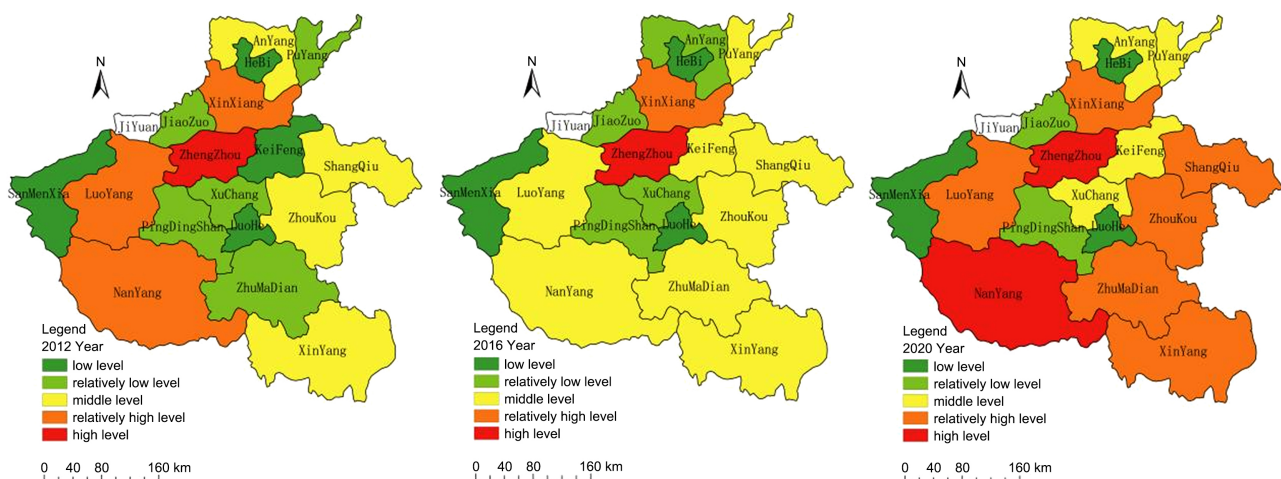

Figure 1. Spatial distribution pattern of the digital economy in Henan cities from 2012 to 2020 Base map from standard map service system (Website: http://bzdt.ch.mnr.gov.cn/index.html).

Table 4. Random Tobit regression results.

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
DIGE	0.0000259*** (4.96)	0.0000231*** (4.51)	0.0000341*** (4.61)	0.0000372*** (4.76)	0.0000385*** (4.97)	0.0001073*** (9.16)	0.0000814*** (7.15)
RGDP		6.04e−06*** (3.48)	−0.0000211 (−1.58)	−0.0000137 (−0.93)	−0.0000428** (−2.22)	−0.0000782*** (−4.41)	−0.0002878*** (−7.66)
HUMA			0.00003** (2.05)	0.000034** (2.27)	0.0000474*** (2.98)	0.0000264* (1.84)	0.0000955*** (5.57)
GOVR				−5.988954 (−1.17)	−7.634656 (−1.50)	12.3893** (2.34)	−14.56609** (−2.26)
FDL					0.8876814** (2.29)	0.7687185** (7.25)	−2.668658*** (−4.20)
INFRA						2.190783** (2.26)	1.88549*** (6.77)
INVEST							0.0052444*** (6.20)
_cons	0.4660947*** (9.06)	0.2529454*** (3.19)	−1.59212* (−1.76)	−1.290134 (−1.38)	−2.557346** (−2.37)	−5.822197*** (−5.52)	−1.821056 (−1.58)
Wald	24.62	38.26	43.09	44.93	51.34	117.83	179.14
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Loglike	−39.1047	−33.1939	−31.1169	−30.4369	−27.8445	−4.4683	13.1773
LR test	88.02***	93.23***	95.11***	95.85***	98.28***	123.05***	143.35***
Obs	243	243	243	243	243	243	243

Note: *, **, ***denote significant at the 10%, 5%, and 1% levels, respectively; SD in (), same as in the following table. The data in the table is calculated from Stata 14.0 software.

promote the high quality development of manufacturing industry in Kaifeng City. Model (2) - (7) With the addition of control variables one by one, it can be concluded that the coefficients of digital economy development level variables are always positive, and they all pass the significance test at the 1% level, but the coefficient values are small, which may be due to the fact that the overall digital economy development level in Kaifeng is in the initial development stage, the digital transformation of manufacturing industry is in the initial stage, and the digital development level of each sub-sector industry is uneven, and the integration of digital economy and each sub-sector industry of manufacturing industry needs to be deepened, so it shows a positive promotion effect, but the boost is not strong. From the control variables, the three variables of human capital, capital investment and infrastructure level all passed the significance test at the 1% level, and the coefficients were all positive, among which the coefficient value of infrastructure level variable was the largest and human capital was the smallest,

which indicated that with the increase of capital investment, the improvement of infrastructure level construction, and the increase of talent training would show positive effects on the high-quality development of manufacturing industry, and the positive effect of infrastructure level on the high-quality development of manufacturing industry was the largest and human capital was the smallest. The level of economic development, government regulation and control, and financial development all pass the significance test at the 5% level with negative coefficients, indicating that economic development, government regulation and control, and financial development have inhibiting effects on the high-quality development of manufacturing industry, among which the inhibiting effect of government regulation is the most significant, probably because under the conditions of market economy, the level of economic development of Kaifeng people is still low, and a certain scale of local economic development has not yet been formed. economic development market to digest manufacturing products, financial development prefers industries with short product production cycle and fast capital return, manufacturing industry has limited financial investment in manufacturing industry due to its long production cycle and relatively low profit, which restricts the expansion and development of manufacturing industry, and the government restricts the development of manufacturing industry due to its severe policies such as environmental protection, but with the setting of manufacturing access white list, manufacturing manufacturing development link after the implementation of green and sustainable development, will achieve high-quality development of the manufacturing industry.

6.4. Robustness Tests

To further verify the robustness of the estimation results, this paper uses mixed OLS model, fixed effects (FE) model, random effects (RE), and mixed Berthon model for regression tests, and from Table 5, we find that the significance of the core explanatory variables and control variables, positive and negative coefficients and the previous random Tobit model results are consistent, indicating that the results of this paper have strong robustness, and further indicating that the choice of random Tobit model is appropriate.

6.5. Industry Heterogeneity Analysis

There may be industry heterogeneity in the impact of the digital economy on the high-quality development of the manufacturing industry under different factor intensities, and this paper uses a stochastic Tobit model to test the impact effect mainly on labor-intensive, capital-intensive and technology-intensive manufacturing industries. As can be seen from Table 6, all three levels of digital economy development passed the significance test at the 1% level and the coefficients were positive, but the degree of influence of the three is capital-intensive manufacturing > labor-intensive manufacturing > technology-intensive manufacturing, in that order. Analyzing the reasons, labor-intensive manufacturing industries

Table 5. Regression results of robustness test.

	(1) OLS	(2) FE	(3) RE	(4) Mixed Berthon Model
DIGE	0.0000776*** (12.03)	0.0000776*** (7.77)	0.0000776*** (7.77)	0.0001679*** (9.64)
RGDP	−0.0002648*** (−8.15)	−0.0002648*** (−8.08)	−0.0002648*** (−8.08)	−0.0005025*** (−8.11)
HUMA	0.0000885*** (4.99)	0.0000885*** (5.94)	0.0000885*** (5.94)	0.000163*** (5.80)
GOVR	−15.31066*** (−3.31)	−15.31066*** (−2.72)	−15.31066*** (−2.72)	−35.06651*** (−4.46)
FDL	−2.410516*** (−6.51)	−2.410516*** (−4.38)	−2.410516*** (−4.38)	−4.700581*** (−6.60)
INFRA	1.766365*** (8.77)	1.766365*** (7.26)	1.766365*** (7.26)	3.671718*** (8.33)
INVEST	0.0048572*** (8.18)	0.0048572*** (6.60)	0.0048572*** (6.60)	0.0095678*** (7.92)
_cons	−1.562622* (−1.78)	−1.562622 (−1.55)	−1.562622 (−1.55)	−4.124301*** (−3.03)
R2	0.2567	0.4960	0.2567	
F-stat	29.63***	29.39***	205.70***	
Wald chi2				101.80
Loglike				−196.31708
Obs	243	243	243	243

The data in the table is calculated from Stata 14.0 software.

Table 6. Random Tobit regression results under different factor intensities.

	Labor-intensive manufacturing	Capital-intensive manufacturing	Technology-intensive manufacturing
DIGE	0.0000785*** (5.44)	0.0000877*** (3.85)	0.000086*** (2.88)
RGDP	−0.0002564*** (−5.42)	−0.0003759*** (−4.91)	−0.0002714*** (−2.73)
HUMA	0.0000626*** (2.90)	0.0001675*** (4.85)	0.0000873* (1.87)
GOVR	−8.089081 (−0.99)	−32.32498** (−2.52)	−4.124764 (−0.24)
FDL	−2.094267*** (−2.63)	−4.904238*** (−3.78)	−1.451625 (−0.86)
INFRA	2.086833*** (5.92)	1.434213*** (2.61)	2.186586*** (2.91)
INVEST	0.46717*** (4.38)	0.0073731*** (4.31)	0.0041856* (1.88)
_cons	−1.36973 (−0.94)	−1.409911 (−0.61)	−3.969671 (−1.32)
Wald	100.88	68.35	27.85
Prob	0.0000	0.0000	0.0000
Loglike	29.7549	0.7159	−9.8235862
LR test	55.45***	35.93***	28.21***
Obs	117	63	54

The data in the table is calculated from Stata 14.0 software.

embed simple processes and trade in the process of digital transformation to achieve initial transformation, capital-intensive manufacturing industries and technology-intensive manufacturing industries are often due to long industrial chains and complex production processes, digital transformation is difficult, resulting in its digital economy to promote its role is limited.

7. Research Conclusions and Realization Path

7.1. Research Conclusion

This paper mainly studies the digital economy and the high quality development of manufacturing industry, and analyzes the connotation requirements, significance and problems of the digital economy to promote the high quality development of manufacturing industry at the theoretical level by combing its literature, and takes Kaifeng city as the object of this study at the empirical level, and first measures the level of high quality development of manufacturing industry and the level of development of digital economy respectively, then analyzes the temporal evolution of manufacturing industry segments in Kaifeng city and the temporal evolution characteristics of digital economy in Henan province, and finally draws the following conclusions. The following conclusions are drawn after empirically testing the impact of digital economy on the high quality development of manufacturing industry and testing the industry heterogeneity under different factor intensity.

First, from 2012 to 2020, except for the negative growth of electrical machinery and equipment manufacturing industry (C38), Kaifeng manufacturing industry as a whole and its sub-sectors are growing in fluctuations, the highest average annual growth rate is in paper and paper products industry (C22), and the average annual growth rate of most industries fluctuates between 10% and 15%. Second, the digital economy in Kaifeng is in a period of rapid development from 2012 to 2020, leapfrogging from the low level stage in 2012 to the medium level stage in 2020, with an average annual growth rate of 21.15%. Thirdly, the digital economy can significantly boost the high-quality development of manufacturing industry, but the strength of the boosting effect is not large. Human capital, capital investment, and infrastructure level show a positive contribution to the high-quality development of manufacturing industry, among which infrastructure level has the largest contribution and human capital has the smallest contribution; The level of economic development, government regulation and control, and the level of financial development show a negative inhibitory effect on the high-quality development of manufacturing industry, among which the inhibitory effect of government regulation is the most significant. Fourthly, there is industry heterogeneity in the digital economy on the high-quality development of manufacturing industry under different factor intensity. The impact of digital economy on the high-quality development of labor, capital and technology manufacturing industries are all positively promoted, but the degree of im-

pact is different, and the magnitude of the three impacts is capital-intensive manufacturing > labor-intensive manufacturing >technology-intensive manufacturing in order.

7.2. Realization Path

According to the above analysis, for the less developed regions, the following paths are needed to realize the high-quality development of the digital economy-enabled manufacturing industry. First, strengthen the construction of digital infrastructure, solidify the foundation of digital empowerment in industrial parks, optimize the spatial layout of digital industrial resources, and strengthen the foundation of digital empowerment in manufacturing industry. Second, focus on the digital transformation of industries with special advantages, take the lead in creating a number of digital manufacturing industries, so as to drive the development of digital transformation of other manufacturing industries and promote the development of deep integration of informationization and industrialization in the manufacturing industry. Third, strengthen the main role of manufacturing enterprises in technological innovation, cultivate the creation of digital "1 + N" R & D platform system, so the manufacturing industry with new vitality. Fourth, improve and optimize the government's preferential support policies, create a good atmosphere for the development of the manufacturing industry, strengthen the support of talents, and accelerate the establishment of a perfect digital ecological development environment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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