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Effect Measurement and Impact of Digital Economy on the High-Quality Development of Manufacturing Industry: A Case Study of Urban Agglomeration in the Pearl River Delta

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Abstract

In the face of profound changes unseen in a century, digital economy and high-quality development of manufacturing industry are advancing together, adding strong impetus to the construction of a new development pattern. In the context of the huge enabling space of digital economy in the development of China's manufacturing industry, this project believes that the existing research ignores the internal mechanism of digital economy on the development of manufacturing industry and lacks theoretical research, and does not consider the interaction between other factors and the high-quality development of manufacturing industry under the background of digital economy. Based on the panel data of nine cities in the Pearl River Delta from 2012 to 2022, this paper measures the transformation and upgrading level of digital economy and manufacturing industry, and explores the internal logic of digital economy enabling the high-quality development of manufacturing industry. This paper empirically analyzes the influence mechanism of digital economy on the high-quality development of manufacturing industry in Pearl River Delta urban agglomeration, and provides policy suggestions for digital economy to promote the high-quality development of manufacturing industry.

Keywords

Digital economy; Manufacturing; Pearl River Delta; Effect measurement; Influence.

1. Introduction

With the deep integration of digital technology into the economy and society, the digital economy has become an important engine for global growth and transformation. As China's economy has entered a stage of high-quality development, it is necessary to promote the deep integration of the digital economy with all industries to enable high-quality development and modernization. The Pearl River Delta urban agglomeration is one of the regions with the most active economic development and the highest degree of openness in China, and the high-quality development level of manufacturing industry is also very high.

According to the report to the 20th National Congress of the Communist Party of China (CPC), the main contradiction facing Chinese society has changed to that between unbalanced and inadequate development and the people's ever-growing needs for a better life. In terms of the external environment, the global outbreak of COVID-19 has had a profound impact on economic development. Unillateralism and trade protectionism have been spreading, the multilateral trading system has been seriously affected, and the world economy faces many risks and uncertainties, such as depression and recession. In terms of the internal environment, China has entered a new normal stage of economic development, and the task of industrial transformation and upgrading is arduous. The manufacturing industry, which is the foundation of China and the foundation of China's national power, has suffered weak development against the background of global manufacturing transformation and upgrading and long standing in the

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middle and low end value chain. Digital economy provides new ideas for solving the problems faced by the development of China's manufacturing industry. Therefore, this paper takes the Pearl River Delta urban agglomeration as an example to explore the effect measurement and impact of digital economy on the high-quality development of manufacturing industry.

2. Literature Review

There are three types of literature related to this study: firstly, the measurement of digital economy; The second is the measurement of the high-quality development of manufacturing industry; The third is the impact of digital economy to enable the high-quality development of manufacturing industry.

At present, there is very little relevant literature on digital economy measurement, and it is limited to the provincial level. Some scholars, such as Zhao Tao and Song Yang, have measured the development level of digital economy from different dimensions, including Internet development, digital financial inclusion, informatization, digital transactions and so on, and constructed relevant evaluation index systems.

2.1. Measurement of digital economy

At present, there is very little related literature on digital economy measurement, and it is limited to provincial level. Some scholars, such as Zhao Tao[1], measure the development level of digital economy from two aspects: Internet development and digital financial inclusion. Song Yang[2] constructed the evaluation index system of digital economy of Chinese provinces from three dimensions: informatization, Internet development and digital transaction.

2.2. Measurement of manufacturing high quality development

In recent years, domestic scholars have begun to study the evaluation of the high-quality development of manufacturing industry. For example, Zhang Wenhui proposed an evaluation system that includes seven first-level indicators, including innovation-driven, structural optimization, speed benefit, factor efficiency, quality brand, integrated development and green development. These evaluation systems aim to comprehensively assess the development level of the manufacturing industry. Liu Chengkun[4] has constructed an evaluation system covering five categories of indicators, namely, transformational development, innovative development, integrated development, green development and enterprise development, to study the comprehensive level of high-quality development of the manufacturing industry.

2.3. Research on the high-quality development of manufacturing industry by digital economy

Domestic researchers mainly study the realization mechanism of digital economy enabling the high-quality development of manufacturing industry from the perspective of technological innovation, factor structure, industrial chain, green transformation and global value chain.

Based on the overall index of digital economy in all provinces in China, Wang Binyan[5] found that technological innovation investment has a positive correlation with the development of digital economy. Zhang Donghua [6]discussed the influence mechanism of digital economy on factor structure and internal upgrading effect from "input-output-environment", focusing on the analysis from three dimensions of input, output and environment. Wan Chengtao [7]analyzed the realization mechanism of how digital economy drives the transformation and upgrading of manufacturing industry from four aspects of industrial chain under the background of digital economy. Based on the panel data of the difference of digital input sources and the level of green development at home and abroad from 2000 to 2012, Ren Xiang[8]ji found that digital economy enables manufacturing industry to promote the green transformation of enterprises. In this paper[9], Xu established an argument framework by

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using fixed effects and regression models, and proved that digital economy plays an important role in promoting the upgrading of global value chain and the transformation of governance structure of traditional manufacturing industry.

In summary, although the existing literature on the measurement and implementation mechanism of the transformation and upgrading of digital economy and manufacturing industry has been very rich, most of them have never been carried out from the research dimension, and few have been studied from the perspective of urban agglomeration. In the context of the Pearl River Delta regional integration strategy, this paper constructs a measurement and implementation mechanism to analyze the transformation and upgrading of digital economy and manufacturing industry from the perspective of urban agglomeration.

3. Research Methods

3.1. Entropy weight method

The entropy weight TOPSIS method is used to measure the digital economy level and the high-quality development level of manufacturing industry in each city in the Pearl River Delta urban agglomeration.

3.2. Spatial measurement

The spatial lag model and spatial error model are established to conduct regression analysis on the digital economy level and the high-quality development level of manufacturing industry in each city in the Pearl River Delta urban agglomeration, and explore the impact of digital economy on manufacturing industry.

4. Data source

This paper uses the China City Statistical Yearbook from 2000 to 2019, the statistical yearbooks of all provinces and cities, and the Peking University Digital Inclusive Financial Index jointly compiled by the Institute of Digital Finance of Peking University and the Research Institute of Ant Technology Group as data sources. For some missing data, interpolation method was used to fill in the data.

5. Empirical analysis

5.1. Effect measurement of digital economy and high-quality development of manufacturing industry

Based on the development characteristics of digital economy, this paper analyzes the three dimensions of digital infrastructure scale, digital industry development level and digital finance development level, among which the scale of digital infrastructure is the number of mobile phone users (ten thousand) and the number of Internet users in 100 people. The development level of digital industry is the number of employees in information transmission and computer service/software industry, the total amount of telecommunications business (10 million yuan) and the total amount of post and telecommunications business (10 million yuan). The development level of digital finance is the digital financial inclusion index of Peking University. The evaluation results of the high-quality development of digital economy and manufacturing industry are obtained by using the entropy weight method and stata econometric analysis, as shown in Table 1. It can be seen from the evaluation results that the overall development level of digital economy in the Pearl River Delta fluctuates, which is related to the vigorous development of science and technology in China in recent years, but declines from 2020 to 2021, which is related to the impact of COVID-19 on China's economy, and the development of science and technology declines due to certain resistance.

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Table 1 Digital economy Development Index of Pearl River Delta cities (evaluation results)

Cities	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Guangzhou	0.6467	0.6462	0.6837	0.6725	0.6362	0.7244	0.8372	0.7535	0.7154	0.7237	0.7635
Foshan	0.6838	0.6255	0.6546	0.7377	0.7462	0.8261	0.8366	0.7256	0.7272	0.6671	0.7412
Zhaoqing	0.2773	0.3627	0.3738	0.4277	0.4562	0.5277	0.4288	0.4627	0.3627	0.3881	0.3571
Shenzhen	0.7256	0.7618	0.8177	0.8372	0.8271	0.9162	0.9336	0.8277	0.8466	0.8526	0.8832
Dongguan	0.6372	0.5878	0.6267	0.5672	0.6676	0.6728	0.7189	0.7283	0.7139	0.6321	0.6277
Huizhou	0.4277	0.5262	0.5482	0.5183	0.6267	0.6725	0.6661	0.5927	0.5172	0.5388	0.5473
the Pearl River	0.6281	0.6183	0.6788	0.6978	0.6355	0.6255	0.7327	0.6212	0.5877	0.5628	0.6289
Zhongshan	0.5278	0.4278	0.6472	0.6672	0.6172	0.6278	0.6355	0.6129	0.6288	0.5662	0.6261
Jiangmen	0.2884	0.3728	0.3256	0.4266	0.4772	0.5367	0.5267	0.5367	0.4672	0.3672	0.3267

This paper combines the thought and concept of high-quality development of manufacturing industry in the new development stage, starts from the four dimensions of economic benefit, innovation benefit, social benefit and environmental benefit, and refers to the index system of many scholars to construct the evaluation system of high-quality development of manufacturing industry, in which economic benefit refers to industrial added value, innovation benefit refers to the total number of invention patents, social benefit refers to the employment position of the secondary industry. The economic benefit refers to the industrial added value, the innovation benefit refers to the total number of invention patents, the social benefit refers to the employment in the secondary industry, and the environmental benefit refers to the comprehensive utilization rate of three wastes. The entropy weight method is used to obtain the evaluation results through stata measurement analysis, as shown in Table 2. It can be seen from the evaluation results that the overall fluctuation of the Pearl River Delta level is increasing, which is related to the high-quality industrial development of China in recent years, but it has declined from 2020 to 2021, which is related to the impact of COVID-19 on China's economy, and the industrial development has declined due to certain resistance.

Table 2 Digital economy Development Index of Pearl River Delta cities (evaluation results)

Cities	2012	2013	2014	2015	2016	2017	2019	2020	2021	2022
Guangzhou	0.7839	0.7937	0.8273	0.8377	0.8462	0.8672	0.9221	0.8623	0.8278	0.8537
Foshan	0.7322	0.7412	0.7542	0.7733	0.7921	0.8183	0.8329	0.7627	0.7271	0.7477
Zhaoqing	0.4679	0.4738	0.4892	0.4923	0.5038	0.5188	0.5527	0.4928	0.4589	0.4948
Shenzhen	0.8027	0.8172	0.8293	0.8488	0.8599	0.8729	0.9021	0.8637	0.8377	0.8588
Dongguan	0.6889	0.6927	0.7293	0.7499	0.7637	0.7882	0.8599	0.7938	0.7823	0.8334
Huizhou	0.5234	0.5388	0.5488	0.5578	0.5672	0.5782	0.5937	0.5399	0.5280	0.6093
the Pearl River	0.6499	0.6399	0.6599	0.6699	0.6789	0.6832	0.7288	0.6621	0.6511	0.6899
Zhongshan	0.5729	0.5899	0.5927	0.6052	0.6122	0.6499	0.6923	0.6293	0.6192	0.6478
Jiangmen	0.4467	0.4627	0.4829	0.5028	0.5167	0.5283	0.5489	0.5279	0.5110	0.5499

5.2. Spatial econometric regression

According to the above measurement results of the effect between the Pearl River Delta digital economy and the high-quality development of manufacturing industry, there is a correlation between the Pearl River Delta digital economy and the high-quality development index of manufacturing industry. In order to determine the relationship between the correlation and the lag term and the error term, that is, whether to choose the spatial lag model or the spatial error model, the spatial econometric model is selected through the test here. The text only gives the

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test results of some periods that are consistent with the spatial correlation test, as shown in Table 3.

Table 3 LM test results of spatial correlation

LM test	Period	Statistics	P-value
LM LAG	2011	1.2681	0.012
Robust LM LAG		0.0074	0.014
LM ERR		1.5053	0.002
Robust LM ERR		0.2446	0.009
LM LAG	2013	1.2649	0.006
Robust LM LAG		0.4155	0.009
LM ERR		2.9788	0.031
Robust LM ERR		2.0303	0.019
LM LAG	2016	1.1262	0.006
Robust LM LAG		0.0064	0.036
LM ERR		1.8118	0.030
Robust LM ERR		0.6920	0.045
LM LAG	2019	0.0048	0.008
Robust LM LAG		1.6038	0.020
LM ERR		0.6633	0.028
Robust LM ERR		2.2623	0.043

Anselin and Florax proposed that: when LM LAG is more statistically significant than LM ERR, and Robust LM LAG is significant and Robust LM ERR is not significant, the spatial lag model is more suitable; On the contrary, when LM LAG is more statistically significant than LM ERR, and when Robust LM LAG is significant but Robust LM ERR is not significant, the spatial error model is more suitable. It can be seen from Table 5 that the statistical values of LM LAG and LM ERR are both significant and less than 0.05, indicating that it is appropriate to establish the spatial econometric model. Then, the panel data are tested to determine whether fixed effect or random effect should be selected. According to the empirical results, the Husama test value has passed the 5% significance level test in the spatial lag model and the spatial error model, so the spatial panel model with fixed effects is selected for analysis, and the results are shown in Table 4.

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Table 4 Spatial estimation results of digital inclusive finance on carbon emissions

Variables	Time	Model	Model
Coefficient	2012	SAR model 0.142*** (0.025)	SEM model 0.226*** (0.041)
λ		0.160 (0.024)	0.184 (0.013)
R^2		0.246	0.231
Likelihood text		443.692	373.535
Husaman test value		33.40 * *	33.28 * *
Fixed effects		is	is
Coefficient	2015	0.148*** (0.022)	0.191*** (0.009)
λ		0.122*** (0.018)	0.184*** (0.038)
R^2		0.297	0.288
Likelihood text		444.712	403.867
Husaman test value		33.77 * *	33.28 * *
Fixed effects		is	is
Coefficient	2018	0.130*** (0.017)	0.258*** (0.023)
λ		0.171*** (0.019)	0.194*** (0.013)
R^2		0.339	0.317
Likelihood text		437.348	387.020
Husaman test value		31.13 * *	30.94 * *
Fixed effects		is	is
Coefficient	2022	0.167*** (0.018)	0.161*** (0.012)
λ		0.133*** (0.014)	0.134*** (0.018)
R^2		0.260	0.251
Likelihood text		454.668	395.037
Husaman test value		37.74 * *	37.97 * *
Fixed effects		is	is

(Note: ***, ** and * indicate passing the hypothetical test at the significance level of 1%, 5% and 10%, respectively, and the value in parentheses under the coefficient is Standard error of robustness)

Comprehensive comparison between SAR model and SEM model shows that the sign of digital economy coefficient is always positive, indicating that the regression results are relatively robust. According to the empirical estimation results, the goodness-of-fit and natural log-likelihood function values of the model are higher than those of the model, indicating that the model has a good fitting effect. Therefore, the empirical results are analyzed based on the model. The digital economy has a positive effect on the high-quality development of the manufacturing industry (Coefficient>0), and the high-quality development level of the manufacturing industry will decrease with the development of the digital economy. The absolute value of the coefficient increases from 0.142 in 2012 to 0.167 in 2022, and the spatial error coefficient is positive, which indicates that there is a significant spatial dependence between the level of digital inclusive finance and carbon emissions. λ From the perspective of SAR model, the coefficient is significantly positive at 1%, indicating that the influence of geographical location and spatial factors cannot be ignored when analyzing the high-quality development level of digital economy and manufacturing industry under the adjacency relationship (the precision threshold has been set by itself). Digital economy breaks through the constraint of geographical location and has spatial spillover effect on the high-quality development level of manufacturing

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industry. That is, the digital economy in this region will also drive the high-quality development of the surrounding manufacturing industry.

6. Policy suggestions

Through the above empirical research, it can be known that digital economy enables the high-quality development of manufacturing industry and there is spatial spillover effect. Therefore, the following policy suggestions are adopted for digital economy to promote the high-quality development of manufacturing industry:

6.1. Formulate policies to support the development of digital economy

The government can introduce a series of policies to encourage enterprises to invest in the research, development and application of digital technologies. These policies can include financial support, tax incentives and subsidies for R&D funds.In terms of policy making, it is necessary to increase government input, strengthen cooperation with enterprises, and promote research and development and innovation in the field of digital economy. At the same time, it is necessary to improve the legal regulatory system for the development of the digital economy, improve relevant laws and regulations such as intellectual property rights and data security, and promote the healthy and orderly development of the digital economy. It is also necessary to strengthen the construction of public digital infrastructure, such as open data resources, cloud computing centers, smart cities, digital transportation, etc., to promote the deep integration of the digital economy and the real economy. By formulating policies to support the development of the digital economy and creating a sound policy environment and innovation ecosystem, we will promote the rapid development of the digital economy and provide new momentum for economic growth.

6.2. We will strengthen the training of digital technology personnel

The digital economy needs a large number of high-quality talents, and the government can increase investment in education and training in the field of digital technology, provide more scholarships and subsidies, and attract more talents to work in related jobs.

6.3. Promote digital transformation of the manufacturing sector

The government can establish digital transformation demonstration bases, provide training and support for enterprises on digital technology, and guide enterprises to accelerate the pace of digital transformation. At the same time, policies can also be formulated to encourage enterprises to introduce advanced digital technology equipment and systems to improve production efficiency and product quality.In terms of digital transformation, it is necessary to promote the application of digital technologies in manufacturing enterprises, including the Internet of Things, artificial intelligence, big data analysis, etc., in order to achieve intelligent, automated and highly integrated production processes. At the same time, it is necessary to build a digital factory with strong computing capabilities and information management capabilities, build a digital manufacturing ecosystem, and achieve digital collaboration and optimization of manufacturing links. In addition, it is also necessary to pay attention to personnel training and skill upgrading, cultivate engineering and technical talents with digital technology application and innovation ability, and promote the transformation and upgrading of industrial workers. By promoting the digital transformation of the manufacturing industry, we can realize the transformation of the production mode, enhance the core competitiveness of the manufacturing industry, and promote the upgrading and sustainable development of the economic structure.

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6.4. Strengthen data security protection

The development of the digital economy cannot be separated from the collection, storage and analysis of data. The government should formulate relevant laws and regulations to strengthen the supervision and protection of data security and protect the interests of enterprises and consumers.

6.5. Strengthen the coordinated development of digital economy and manufacturing industry

The government can promote the deep integration of digital economy and manufacturing, encourage enterprises to carry out cross-industry cooperation, and expand more digital application scenarios. The government can also provide relevant policy support to encourage enterprises to carry out innovation and entrepreneurship in the digital economy.In terms of the digital economy, it is necessary to promote the wide application of digital technologies, including artificial intelligence, big data, cloud computing, Internet of Things, etc., to enhance the intelligence, automation and flexibility of the manufacturing industry, and improve production efficiency and product quality. In the manufacturing industry, it is necessary to actively explore innovative business models, cultivate digital industrial clusters, promote the deep integration of manufacturing and the digital economy, and promote the transformation of traditional manufacturing to high-end intelligent manufacturing. By strengthening the coordinated development of the digital economy and manufacturing industry, the full integration of digital technology into the manufacturing industry will be realized, the core competitiveness of the industry will be enhanced, and the upgrading and sustainable development of the economic structure will be promoted.

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