Analysis of the Impact of Digital Economy on the Development of Manufacturing Industry

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Abstract. The application of digital technology has provided a fresh boost to the manufacturing industry, infusing it with new momentum. This study focuses on the development of the manufacturing industry in 30 provinces across China from 2011 to 2020, examining the influence of the digital economy on its growth and further exploring the effects of industrial agglomeration. The findings suggest that the digital economy positively influences the development of the manufacturing industry, and that industrial agglomeration serves as an effective intermediary in this process. Finally, using a spatial econometric model, it was found that the positive impact of the digital economy has the characteristic of spatial spillover.

Keywords: digital economy, manufacturing industry, intermediary effect, spatial spillover

1 Introduction

Over the past few years, the digital economy has demonstrated significant potential for development, marking a shift from an agricultural and industry-dominated economic model to a digital economy dominated by digital technology[1]. This new form of economy comprises two key components: the commercial application of digital technologies, known as digital industrialization, and the utilization of these technologies to impact existing industries, known as industrial digitalization. Industrial digitalization primarily refers to the enabling role of the digital economy, measured by its added value in traditional industries. Accelerating the development of the digital economy aims to achieve industrial digitalization.

From a structural standpoint, industrial digitalization has reached a scale of 37.2 trillion-yuan, accounting for 32.5% of GDP, with a nominal year-on-year increase of 17.2%. However, China's manufacturing industry still faces the challenge of being "big but not strong", characterized by the transfer of low-end manufacturing to Southeast Asian countries due to the implementation of "manufacturing reshoring" policies in Western nations and the rise in local labor costs in China. Consequently, China's manufacturing industry is affected from both sides, China's current position in the global manufacturing division falls short of dominating core technology standards and patents, as exemplified by the United States and Germany. Similarly, China still trails behind in terms of manufacturing large-scale integrated circuit chips and high-end consumer electronic products, areas in which Japan and South Korea hold the lead. Chinese position in the global industrial chain division of labor remains relatively low.

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Promoting the transformation of China's manufacturing industry and progressing from a manufacturing country to a manufacturing powerhouse has become a crucial practical issue in enhancing its development. In this regard, the enabling role of the digital economy in the current industry is considered an important pathway towards achieving development in China's manufacturing industry [2]. As a result, effectively harnessing the enabling role of the digital economy in the development of the manufacturing industry has garnered significant attention from scholars in recent years.

Previous research has explored various paths and direct effects of the digital economy on the development of the manufacturing industry. These studies have investigated factors such as dual innovation[3], consumption structure, industrial transformation and upgrading, industrial agglomeration, and the improvement of manufacturing production efficiency through the digital economy. However, research on manufacturing industry agglomeration has been limited to individual regions, and national data has not been extensively studied. Therefore, this paper aims to examine the national digital economy from the perspective of manufacturing industry agglomeration at the provincial level.

Manufacturing industry agglomeration is characterized by the localization of production activities among manufacturing enterprises within the same or similar geographic areas, resulting in spillover effects and increased output efficiency[4]. These spillover effects enable firms to achieve greater output with the same level of input.

This research paper focuses on constructing an analytical framework centered on manufacturing industry agglomeration. It assesses the index of the digital economy and the manufacturing industry development across 30 provinces from 2011 to 2020. By employing methodologies such as fixed effects, intermediary effect analysis, spatial econometric model, This research investigates the impact of the digital economy on manufacturing industry growth and delves into its underlying operational mechanisms. The findings highlight that the digital economy has a favorable influence on the progress of the manufacturing industry, with industrial agglomeration emerging as a significant factor influencing this relationship. The digital economy also positively influences the spatial development of the manufacturing industry.

2 Theoretical analyses

2.1 Digital economy and development of manufacturing industry

With the continuous advancement of the digital economy, its influence on the manufacturing industry has deepened significantly. It is no longer limited to surface-level impacts but extends to the core operations of the manufacturing sector. The digital economy has increasingly emerged as an intrinsic driving force for the development of the manufacturing industry[5~6].

The digital economy's development facilitates the seamless flow of information, which plays a critical role in production processes. Manufacturing enterprises can effectively reduce the costs associated with information search, improve production efficiency, and gain a better understanding of consumer needs. This, in turn, leads to enhanced profitability. Additionally, the inclusive and shared nature of the digital economy allows for powerful knowledge sharing through digital platforms. This fosters knowledge spillover and stimulates innovation within manufacturing enterprises. Given the aforementioned analysis, we can propose the following hypothesis:

Hypothesis 1: The digital economy has a positive impact on promoting the development of the manufacturing industry.

2.2 The intermediary role of industrial agglomeration

Based on existing research, specialized industrial agglomeration within the manufacturing industry has been shown to effectively promote its development. This is primarily achieved through the promotion of industrial division of labor and knowledge spillover, which makes the industry more specialized, refined, and efficient. This ultimately reduces operating costs, while also further promoting manufacturing industry development through improved production efficiency. As the digital economy continues to evolve, the knowledge spillover role of industrial specialization agglomeration has become even more pronounced, especially given the development of digital platforms. This has led to an improvement in information transparency surrounding product demand and supply, which in turn allows enterprises to better understand demand side requirements, market information dynamics, and ultimately better match demand requirements, lower operating and information search costs, and form a differentiated product supply to better serve the market. As a result:

Hypothesis 2: The digital economy can promote development within the manufacturing industry through the mediating role of industrial agglomeration.

2.3 The positive spatial spillover effect of the digital economy

The digital economy's convenience in data transmission and information delivery is a key feature, which can effectively enhance the spatial spillover effect. According to existing research, the use of the Internet can effectively promote spatial spillover[7~9]. Hence, the digital economy, encompassing the Internet, should yield a positive spatial spillover effect on the manufacturing industry's development, thereby catalyzing growth in the surrounding areas. As a result:

Hypothesis 3: Spatial spillover effects enable the digital economy to effectively enhance the development of the manufacturing industry in neighboring regions.

3 Research design

3.1 Model construction

Hypothesis 1, hypothesis 2 was tested by mediating effect model. First, a basic model of the direct effect mechanism is constructed:

$$Zzygzl_{i,t} = \alpha_0 + \alpha_1 Dige_{i,t} + \alpha_2 Z_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \tag{1}$$

In equation (1), $Zzygzl_{i,t}$ represents the level of development in the manufacturing industry for province i at time period t. $Dige_{i,t}$represents the indicator of digital economy development for province i at time period t. Vector $Z_{i,t}$ represents a series of control variables. μ_i, δ_t,$\varepsilon_{i,t}$represent the individual fixed effect, time fixed effects and the random disturbance term.

$$Zzy_{i,t} = \beta_0 + \beta_1 Dige_{i,t} + \beta_2 Z_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

$$Zzygzl_{i,t} = \gamma_0 + \gamma_1 Dige_{i,t} + \gamma_2 Zzy_{i,t} + \gamma_3 Z_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

After conducting regression analysis to examine the relationship between manufacturing industry agglomeration and the digital economy, equation (2) is derived. Subsequently, the study tests whether manufacturing industry agglomeration mediates. To investigate this, both the digital economy development index and the intermediary variable of manufacturing industry agglomeration are simultaneously included in the model, resulting in equation (3). Equation (3) is then utilized to assess whether manufacturing industry agglomeration functions as an intermediary variable between the two factors.

Finally, to verify whether there is a spatial spillover effect of the digital economy on the development of the manufacturing industry, this paper introduce a spatial econometric model.

$$Zzygzl_{i,t} = \alpha_0 + \rho WZzygzl_{i,t} + \alpha_1 Dige_{i,t} + \alpha_2 Z_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (4)$$

In equation (4), After testing, the SAR model was used for spatial metrology. $WZzygzl_{i,t}$ represents the spatial lag term, which eliminates autocorrelation through the regression of $Zzygzl_{i,t}$ and its neighboring $Zzygzl_{i,t}$ values; ρ is the spatial autoregressive coefficient, measuring the overall interdependence strength among regions, with ρ=0 indicating no correlation. 0-1 spatial geographic matrix is employed in this study.

3.2 Measurement and explanation of variables

Explanatory variable: Manufacturing Development Index (Zzygzl). Drawing on the research of Huang Shunchun and Zhang Shuqi (2021) [10], is measured using a comprehensive evaluation index system. This system includes 10 indicators, such as GDP and total profit. The specific indicators and their measurements can be found in Table 1.

Table 1. Index system for development of manufacturing industry.

Indicator Definition	Attribute
Output	+
Operating profit/revenue from main business	+
Total profit	+
The number of patents of the enterprise	+
Number of R&D personnel	+
R&D expenses for new products/revenue from new products	+
Solid waste discharge/revenue from main business	-
Waste water discharge/main business income	-
SO_2 emissions/revenue from main operations	-
Electricity consumption/main business income	-

In this paper, the objective weighting method known as the entropy method is utilized to calculate the comprehensive evaluation value of the manufacturing industry's development in each province.

The core explanatory variable employed in this study is the Digital Economy Development Index (DIGE). To construct this index, this paper adopts the measurement methodology of Zhao Tao et al. (2020) [11] for assessing the digital economy. They have identified five secondary evaluation indicators, as outlined in Table 2. The indicator is constructed using the entropy weight method.

Table 2. Comprehensive evaluation index system of digital economy.

Indicator Definition	Attribute
Internet users per 100 people	+
Percentage of computer and software employees	+
Total telecommunications services per capita	+
Mobile phone subscribers per 100 people	+
China Digital Financial Inclusion Index	+

Intermediary variable: manufacturing agglomeration level (zzy). This paper used location entropy as a means to represent this level. The measurement method for location entropy is as equation (5).

$$LQ_j = \frac{e_{i,j}/E_j}{E_i/E} \quad (5)$$

By utilizing location entropy, can evaluate and compare the degree of manufacturing agglomeration across different regions or areas.Among these indicators, $e_{i,j}$ represents the output value of industry i in region j; E_j denotes the gross output value of region j; E_i represents the output value of industry i in the entire region; and E signifies the overall gross output value of the entire region.

Control variables: Refer to other literatures and select the following control variables, as shown in Table 3.

Table 3. Control variables.

Control variables	Indicator composition
Fiscal Decentralization (Finadp).	Revenues to expenditures within the budget
Level of economic development (lnGDPP)	GDP per capita
Foreign Investment (FDI)	Annual actual use of foreign capital as per GDP
Finance	Institutional deposits and loans to GDP ratio

3.3 Data sources and descriptive statistics

According to the findings presented in Table 4 of the study, there are considerable variations in the level of development of the manufacturing industry (Zzygzl) among the 30 provinces in China from 2011 to 2020. The maximum value observed is 0.93, while the minimum value is 0.10. The average value is 0.37, indicating that there is still significant room for improvement in terms of development across the provinces. This suggests that some provinces have achieved a relatively high level of development in terms of quality, while others are lagging behind.

Similarly, the digital economy development level (DIGE) also displays significant disparities among the provinces. The maximum value recorded is 0.98, while the minimum value is 0.08. The standard deviation of 0.17 suggests an imbalance and differences in the level of digital economy development among the provinces. Some provinces have made substantial progress in the development of the digital economy, whereas others remain at a relatively lower level.

Furthermore, the study highlights imbalances and notable differences among the control variables, including regional economic development level, foreign investment, fiscal decentralization, and financial development level. This indicates that there are significant variations in these control variables across the different provinces in China.

Table 4. Descriptive statistical results of variables.

variable	Number of observations	mean	standard deviation	minimum	maximum	median
Zzygzl	300	0.37	0.15	0.10	0.93	0.36
Dige	300	0.37	0.17	0.08	0.98	0.34
zzy	300	0.86	0.38	0.26	2.36	0.85
LnGDPP	300	10.79	0.44	9.68	12.01	10.75
FDI	300	0.02	0.02	0.00	0.12	0.02
Finadp	300	0.50	0.19	0.15	0.93	0.45
Finance	300	3.35	1.09	1.68	7.58	3.11

4 Empirical analysis

4.1 Benchmark regression results

In this paper, a benchmark regression is conducted using a dual fixed-effect model that incorporates both individual and time effects. The core independent variable used is the Digital Economy Development Index (Dige), while the core dependent variable is the Manufacturing Development Index (Zzygzl). The results of the regression model can be found in Table 5.

Control variables are included in model (2), allowing for a comparison with model (1). Both models exhibit significantly positive coefficients for Dige. This implies that, at the provincial level, the advancement of the digital economy plays a vital role in fostering development within the manufacturing sector.

The regression results in model (2) further reveal a positive correlation between the level of economic development and the development of the manufacturing industry in each region. This implies that as the regional economy improves, it contributes to the advancement of development in the manufacturing industry. However, the coefficient value of foreign investment is positive but not statistically significant, indicating that foreign investment may not have a significant impact on advanced manufacturing technology or the development of the manufacturing industry.

Furthermore, the coefficients of fiscal decentralization and financial development level are both negative and not statistically significant at the 10% level. This implies that the development of the financial sector in the provinces may not be conducive to the growth of the manufacturing industry in the region. This could be due to the financial industry's focus on virtual or speculative activities, which may divert resources away from the manufacturing sector's real production and innovation.

Table 5. Benchmark regression results.

variable	Zzygzl	
	(1)	(2)
Dige	0.509*** (0.125)	0.316** (0.125)
LnGDPP		0.186*** (0.049)
FDI		0.348 (0.219)
Finadp		-0.008 (0.087)
Finance		-0.005 (0.012)
Individual fixation	YES	YES
Time fixation	YES	YES
Number of periods	10	10
Number of individuals	30	30
R^2	0.060	0.161

Note: *p<0.1; **p<0.05; p<0.01.

In the following analysis, we will explore the mediating role of industrial agglomeration in the context of the manufacturing industry. Our study utilizes a regression model (REG) to empirically examine the mediating effect, with the detailed regression results provided in Table 6. The findings from Model (2) reveal a significant and positive coefficient for the core explanatory variable, Dige, providing compelling evidence for the favorable impact of digital economy development on industrial agglomeration within the manufacturing industry.

Moving forward, Model (1) introduces the mediating variable of industrial agglomeration, resulting in Model (3). We apply the regression model (REG) with the mediating effect to evaluate the criterion. Upon scrutinizing the changes in coefficient values and the significance of the explanatory variable, we observe a decline in the impact coefficient of digital economy development on development in the manufacturing industry, shifting from 0.316 to 0.222 within Model (3). This decrease remains statistically significant at the 10% level. These findings suggest that industrial agglomeration serves as a crucial mechanism through which the digital economy fosters development within the manufacturing industry. However, it is important to note that industrial agglomeration is not the sole mediating variable, partially supporting the judgment of the mediating effect model and ultimately validating Hypothesis 2 based on empirical results.

Table 6. Regression results of mediating effect.

variable	Zzygzl (1)	Zzy (2)	Zzygzl (3)
Dige	0.316** (0.125)	1.033** (0.510)	0.222* (0.118)
Zzy			0.091*** (0.014)
Control variables	YES	YES	YES

Individual fixation	YES	YES	YES
Time fixation	YES	YES	YES
Number of periods	10	10	10
Number of individuals	30	30	30
R^2	0.161	0.085	0.276

Note: *p<0.1; **p<0.05; p<0.01.

4.2 Analysis of spatial spillover effects

In the first step, a test for spatial effects is performed, using the Moran's I index to assess spatial autocorrelation. Table 7 presents the Moran index of the digital economy development index and the manufacturing development index from 2011 to 2020 based on a spatial distance matrix of 0-1. As indicated by the table, the Moran index has achieved a significant level of 5%, indicating a substantial positive spatial autocorrelation in the development of the digital economy and manufacturing industry across all provinces of China from 2011 to 2020.

Table 7. Moran's I.

Year	Dige		Zzygzl	
	Moran's I	Z	Moran's I	Z
2011	0.230***	2.994	0.213***	2.643
2012	0.242***	3.161	0.197***	2.478
2013	0.206***	2.736	0.182***	2.332
2014	0.187***	2.573	0.215***	2.663
2015	0.163***	2.302	0.183***	2.349
2016	0.184***	2.585	0.173***	2.239
2017	0.153***	2.198	0.177***	2.291
2018	0.152***	2.146	0.193***	2.502
2019	0.167***	2.320	0.174***	2.318
2020	0.187***	2.574	0.179***	2.376

Next, Table 8 presents the findings of the spatial regression model examining the relationship between digital economy and manufacturing development using the 0-1 spatial weight matrix. The results in Table 8 demonstrate a significant spillover effect of the digital economy on the manufacturing industry's development, thereby confirming the validity of hypothesis 3.

Table 8. Spatial econometric regression results.

variable	Zzygzl
ρ	0.124** (0.059)
Dige	0.306** (0.114)
LnGDPP	0.167*** (0.045)
FDI	0.364* (0.200)
Finadp	-0.021 (0.080)
Finance	-0.024 (0.011)

Individual fixation	YES
Time fixation	YES
Number of periods	10
Number of individuals	30
R^2	0.278

Note: *p<0.1; **p<0.05; p<0.01.

4.3 Robustness test

The mediation effect model utilized in this article is the regression mediation effect model (REG). Consequently, a structural equation model (SEM) is adopted to examine the robustness of the mediation effect model. Specifically, the outcomes derived from REG are subjected to MEDSEM analysis, and the results presented in Table 9 are obtained. Both the Zhao test and BK test indicate the existence of partial mediation. Roughly 46.5% of the total effect is attributed to the mediation effect of agglomeration in the manufacturing sector. Therefore, the results have passed the robustness test.

Table 9. Results of MEDSEM.

	Value
Bk test	partial mediation
Zhao test	partial mediation
Indirect effect	0.104
Direct effect	0.120
Total effect	0.224

5 Conclusions and recommendations

This study explores several key findings have emerged:

Firstly, the digital economy has a positive impact on the development of the manufacturing industry. This highlights the importance of the digital economy in driving the growth and advancement of manufacturing.

Secondly, industrial agglomeration within the manufacturing sector acts as a critical intermediary for the digital economy in promoting manufacturing development. This indicates that the concentration of manufacturing industries can enhance the benefits and synergies derived from the digital economy in promoting manufacturing development.

Thirdly, there is a significant positive space spillover of the digital economy in promoting the development of the manufacturing industry.

Based on these research findings, several countermeasures and suggestions can be put forward to promote the development of the manufacturing industry:

1.Promote the development of the digital economy: A strong emphasis should be placed on advancing the digital economy, as it serves as the foundation for computing power, algorithms, and data. One particularly crucial aspect is the development of the semiconductor industry. Strengthening computing capabilities through cutting-edge semiconductor technology is essential for establishing a solid foundation for the digital economy.

2.Accelerate industrial digitalization: Traditional industries should undergo digital transformation to fully leverage the potential benefits of the digital economy. The digitalization process can enhance the efficiency and productivity of traditional industries, ultimately leading to their high-quality development.

3.Construct a unified national market: Currently, data circulation between administrative units is often hindered by barriers and protectionism. To overcome this, the establishment of a unified national data market is essential. By breaking down traditional administrative divisions and promoting a large-scale industrial agglomeration across administrative regions, the circulation of data elements can be facilitated, fostering a more efficient and integrated national market.

4. Strengthening talent development:emphasis should be placed on nurturing professionals in the field of digital economy, such as data analysts, artificial intelligence experts, and cybersecurity specialists, to meet the increasing demand in this rapidly expanding field. Additionally, there should be a focus on education and training programs that provide digital economy-related courses to enhance overall awareness and understanding of the digital economy across society. By strengthening technology innovation and talent development, we can further promote the healthy and sustainable growth of the digital economy.

References

[1] Li Sanxi, Huang Zhuo.Digital economy and high-quality development: mechanism and evidence[J].Economics (Quarterly),2022,22(05).

[2] Du Jinzhu, Wu Zhanyong, Hu Wenxiu, Wu Xinke.Digital economy and high-quality development of manufacturing industry: influencing mechanism and empirical evidence[J].Statistics and Decision,2023,39(07).

[3] Wang Wenyi, An TongliangIndustrial agglomeration, innovation and knowledge spillover: An empirical study based on China's manufacturing listed companies[J].Industrial Economics Research, 2014, (4).

[4] Tian Gangyuan, Chen Fuliang.Digital economy, industrial agglomeration and high-quality development of manufacturing industry in the Yellow River Basin[J].Statistics and Decision,2022,38(21):

[5] Huang Qunhui, Yu Yongze, Zhang Songlin.Internet Development and Manufacturing Productivity Improvement: Internal Mechanism and Chinese Experience[J].China Industrial Economics,2019,(8).

[6] Jiao Yong.Digital economy empowers the transformation of manufacturing industry: from value remodeling to value creation[J].Economist,2020,(6).

[7] Lin J.，Yu Z.，Wei Y. D.，Wang M.，2017,“Internet Access，Spillover and Regional Development in China”，Sustainability，9(6)，pp.946.

[8] Keller W.，2002,“Trade and the Transmission of Technology”,Journal of Economic Growth，7(1).

[9] Yilmaz S.，Haynes K. E.，Dinc M.，2002,“Geographic and Network Neighbors：Spillover Effects of Telecommunications Infrastruc- ture”，Journal of Regional Science，42.

[10] Huang Shunchun, Zhang Shuqi.A review of the research on the evaluation index system of high-quality development of China's manufacturing industry[J].Statistics and Decision,2021,37(02):5-9.)

[11] Zhao Tao, Zhang Zhi, Liang Shangkun.Digital economy, entrepreneurial activity and high-quality development——Empirical evidence from Chinese cities[J].Management World,2020,36(10).