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A Case Study of China: Influence of Digital Economy on Manufacturing Development

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Abstract: With the advent of the digital age, digital economy has become a major propulsion for the global economy. For manufacturing, digitalization has brought unprecedented opportunities and challenges, transformed production processes and impacted aspects such as marketing and supply chain management. Especially in China, digital transformation has brought notably changes to manufacturing. This paper examines the relationship between the digital economy and manufacturing development by analyzing data from 30 provinces in China from 2011 to 2022. This paper adopts the entropy method to construct a comprehensive evaluation system of digital economy and manufacturing development and uses the panel regression model to conduct an empirical analysis. The results show that the expansion of the digital economy significantly supports manufacturing development, especially in terms of increasing productivity, cutting costs, and allocating resources as efficiently as possible. Additionally, this paper finds that digital lifestyles and digital knowledge environments significantly foster manufacturing development. On the other hand, technological innovation and skilled labor are the key factors for manufacturing development. This paper provides theoretical and practical insights for the integration of digital technologies and the real economy, offering guidance for high-quality and sustainable manufacturing development.

Keywords: Digital economy, Manufacturing development, Entropy method, Panel regression model.

1. Introduction

With the advent of the digital era, the digital economy has become one of the important engines of global economic development. In the era of information explosion, the widespread use of digital technologies is notably changing the mode of operation and development among each industry. As one of the pillars of the global economy, manufacturing is facing unprecedented opportunities and challenges under the trend of digital economy.

Digital economy in China has developed rapidly over the past few years. From 2012 to 2023, the scale of digital economy in China expanded 3.8 times. In 2023, it accounted for 42.8 percent of GDP, with the added value of core industries exceeding RMB 12 trillion. Digital infrastructure in China continues to improve, with well-developed network and computing power facilities, indicating the booming of digital industrialization, and the rise of new digital industries with a well-developed industrial ecosystem. Additionally, digital transformation is facilitating in various industries, which are deepening integration with digital technologies.

Manufacturing, the pillar of national prosperity, is an important part of national economic development. In other words, it is of great importance to national prosperity. Currently, the economy of China has advanced to a high-quality development stage. As an important engine of high-quality development of China’s economy, manufacturing enterprises are the key role in improving quality and efficiency. However, Chinese manufacturing enterprises still have obvious weaknesses currently, such as poor innovation, which makes it difficult to meet the needs of high-quality development of the economy. Especially under the influence of the current complex international environment, how to rapidly improve the development has become an urgent issue for Chinese manufacturing enterprises. In this background, it is important to strengthen the core competitiveness of manufacturing, and enhance market competitiveness, turning “large but not strong” into “strong and high-quality”.

The increase in the level of digitization provides multi-dimensional propulsion for the rapid development of digital economy. First of all, the core elements of digital economy, such as big data, cloud computing and artificial intelligence, significantly improve manufacturing process, realize automated production, reduce manpower costs and labor use, and improve productivity and quality, directly promoting the innovation and productivity in manufacturing. On top of that, digital transformation through supply chain management and intelligent manufacturing systems makes manufacturing respond more flexibly to market demand and enhances market competitiveness. Lastly, the wide use of digital technology promotes the transformation of manufacturing into service-oriented manufacturing and expands the business scope and value chain of manufacturing, further promoting industrial upgrading. In conclusion, the development of digital economy not only provides new opportunities for manufacturing development but also is the main propulsion of promoting manufacturing development to higher quality and higher efficiency. For example, Tao and Li analyzed the positive impact of digital economy on manufacturing; Qin et al. found that Chengdu has made progress but is still not as good as Beijing through the comparison between Chengdu and Beijing; Fu and Liu pointed out that the synergy between industrial digitalization and manufacturing in the Yangtze River Delta region has strengthened; Duan and Xu emphasized that digital transformation promotes high-quality development, but inter-regional coupling differences still exist [1-4]. Moreover, Zhao discussed how big data drives manufacturing innovation; Wang et al. found that artificial intelligence can improve the performance of manufacturing in an IoT environment; Chao et al. proposed a decision support model for assessing manufacturing risks; Zhang et al. studied the impact of digital economy networks on promoting green innovation in manufacturing enterprises [5-8]. On the other hand, Kim et al. discussed the key role of ICT infrastructure in transforming manufacturing in emerging markets in Asia; Lola and Bakeev analyzed the propulsions and obstacles of digital transformation in Russia; and Urgo et al. demonstrated specific ways that digital technology enhances industrial production efficiency [9-11].

Overall, previous research mainly focuses on qualitive analysis and lacks comprehensive quantitative studies and measurement systems. This paper uses data from 30 provinces in China to explore the relationship between digital economy and manufacturing. In other words, this paper delves into the interaction between digital economy and manufacturing, which will help reveal opportunities and challenges in development, and provide guidance for promoting China's manufacturing towards higher quality and sustainable development.

2. Methodology

The data ranges from 2011 to 2022, covering a total of 12 years. This paper chooses the data from 30 provinces and municipalities in China, without Tibet due to missing data. The data about manufacturing development and digital economy come from the China Statistical Yearbook, Industrial Statistical Yearbook, China Insurance Yearbook, China Environmental Statistical

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Yearbook, China Financial and Socioeconomic Development Statistical Database, and the National Bureau of Statistics Database. The sample size of this paper is 360.

2.1. Indicator Construction

The indicators of manufacturing development and the digital economy are given weights in this article using entropy technique. Due to the differences of magnitude and units among each indicator, it is necessary to perform standard deviation processing on each raw indicator before constructing the indicators by the entropy method, in order to eliminate the impact of units. After that, the indicators are weighed. Lastly, the weighted and standardized values of the indicators are calculated to obtain the indicator levels of each province.

2.2. Model Construction

In order to examine the impact of the digital economy on manufacturing development, this paper constructs the following regression model in Equation (1).

$$Mfg_{it} = \alpha + \beta_1 Dig_{it} + \beta_i X_{it} + \varepsilon_{it} \quad (1)$$

In this model, Mfg_{it} is the explained variable, manufacturing development. Dig_{it} is the explanatory variable, digital economy. X_{it} represents the control variables, and β_i is the coefficient of the control variables. Control variables include government fiscal expenditure (Gov), industrial structure (Ind), regional economic development level (LnGDP), and infrastructure (LnRoad). α is the intercept, and ε_{it} is the random error term. When $\beta_1 > 0$, as the level of digital economy increases, the level of manufacturing development increases.

3. Results

3.1. Calculation of Manufacturing Development Index

In Table 1, the largest weight in secondary indicators is open development, at 34.32%. This is followed by industrial coordination at 26.37%, technological innovation and economic efficiency at 21.68% and 12.04%. Green development has the lowest weight at 5.21%. Regarding the tertiary indicators, the largest weight is assigned to foreign capital openness and the advancement of the manufacturing industrial structure, while the smallest weight is assigned to the amount of industrial solid waste produced for each unit of industrial value added.

Table 1: Entropy Value and Weight of Manufacturing Development

Secondary Indicators	Tertiary Indicators	Entropy Value	Weight	Ranking	Weight of Secondary Indicators
Technological Innovation	R&D Spending Ratio	0.9025	0.0578	7	0.2168
	Per Capita Patent Count	0.9355	0.0389	8	
	Extent of Engagement in R&D by Personnel	0.8027	0.1202	4	
Green Development	Consumption of Energy per Industrial Added Value Unit	0.9777	0.0135	14	0.0521
	Sulfur Dioxide Emissions Relative to Each Unit of Industrial Output	0.9733	0.0163	11	

Table 1: (continued).

	Amount of Industrial Solid Waste Produced for Each Unit of Industrial Value Added	0.9894	0.0065	15	
	Chemical Oxygen Demand of Wastewater per Unit of Added Value	0.9739	0.0159	12	
Open Development	Foreign Trade Openness	0.7504	0.1512	3	0.3432
	Foreign Capital Openness	0.6830	0.1920	1	
Economic Efficiency	Manufacturing Growth Rate	0.9622	0.0228	10	0.1204
	Profit Margin of Manufacturing Enterprises	0.9457	0.0329	9	
	Manufacturing Labor Productivity	0.8939	0.0647	6	
Industrial Coordination	Manufacturing Value Added Weight	0.9744	0.0155	13	0.2637
	Industrial Structure Advancement	0.7323	0.1613	2	
	Share of Value Added by the Tertiary Sector	0.8509	0.0906	5	

3.2. Caluculation of Digital Economy Index

In Table 2, the largest weight in secondary indicators is digital industry development, at 47.22%. This is followed by digital infrastructure at 40.98%, and digital inclusive finance at 11.79%. For the tertiary indicators, the largest weight is the number of information enterprises, at 16.04%. This is followed by software industry revenue (in 10,000 yuan) at 14.22%. The smallest weight is web presence ratio per 100 companies, at 1.86%.

Table 2: Entropy Value and Weight of Digital Economy

Secondary Indicators	Tertiary Indicators	Entropy Value	Weight	Ranking	Weight of Primary Indicators
Digital Infrastructure	Number of Domains	0.8090	0.1029	5	0.4098
	Number of IPv4 Addresses	0.7901	0.1150	3	
	Number of Internet Broadband Access Ports	0.9179	0.0450	9	
	Mobile Phone Penetration Rate	0.9178	0.0449	10	
	length of fiber optic cable per unit of coverage	0.8132	0.1020	6	
Digital Industry Development	Number of Information Enterprises	0.7071	0.1604	1	0.4722
	Web Presence Ratio per 100 Companies	0.9658	0.0186	13	
	Volume of E-commerce Transactions (in hundreds of millions of yuan)	0.8069	0.1058	4	

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Table 2: (continued).

	Proportion of Enterprises Engaged in E-commerce Transactions	0.9171	0.0453	8	
	Software Industry Revenue (in 10,000 yuan)	0.7405	0.1422	2	
Digital Inclusive Finance	Index of Digital Financial Accessibility	0.9117	0.0484	7	0.1179
	Depth of Digital Financial Services Usage Index	0.9321	0.0373	11	
	Level of Inclusion in Digital Finance	0.9410	0.0323	12	

3.3. Empirical Analysis

3.3.1. Descriptive Statistics

In Table 3, the Manufacturing Development Index ranges from 0.0606 to 0.6978, with a mean value of 0.2211. Digital Economy ranges from 0.0285 to 0.7345, with a mean value of 0.1978. The mean value of government fiscal expenditure is 0.2589. The mean value of the infrastructure variable is 0.8504, with a minimum of 0.1300 and a maximum of 2.1200, indicating significant differences in infrastructure levels among different provinces. The mean value of the industrial structure is 1.3536. The mean value of regional economic development level is 10.8684, indicating a high level of economic development in each region.

Table 3: Descriptive Statistics

Variable	N	Mean	Standard Deviation	Minimum Value	Median	Maximum Value
Mfg	360	0.2211	0.1288	0.0606	0.1792	0.6978
Dig	360	0.1978	0.1758	0.0285	0.1337	0.7345
LnGDP	360	10.8684	0.4608	9.6818	10.8325	12.1564
Gov	360	0.2589	0.1116	0.1050	0.2310	0.7583
Ind	360	1.3536	0.7446	0.5271	1.2012	5.2829
LnRoad	360	0.8504	0.4095	0.1300	0.8950	2.1200

3.3.2. Regression Analysis

From the results of the panel regression model in Table 4, it can be observed that the coefficient of the digital economy (Dig) is positive and significant, with a coefficient of 0.707. This suggests that the level of manufacturing development in China can rise dramatically as the digital economy expands. Manufacturing development rises by 0.707 units for every unit growth in digital economy, suggesting that digital economy is a significant factor in fostering manufacturing development.

Table 4: Regression Results

	(1)
	m1
VARIABLES	Mfg
Dig	0.707***

Table 4: (continued).

	(31.568)
LnGDP	0.025***
	(3.111)
Gov	0.154***
	(4.854)
Ind	-0.005
	(-1.138)
LnRoad	0.015***
	(3.250)
Constant	-0.220**
	(-2.533)
Observations	360
R-squared	0.861
F	438.2

Note: T-values are values enclosed in parenthesis. Significance levels at 1%, 5%, and 10% are denoted by ***, **, and *.

3.3.3. Robustness Test

Due to a lag in the digital economy's impact on industrial development, digital economy with a one - period lag will be used as the explanatory variable for regression. The results are shown in column 1 of Table 5. Meanwhile, because the development of actual economies like manufacturing may be impacted by the COVID-19 epidemic, affecting the accuracy of the regression results in this paper. Thus, this paper deletes the samples after the COVID-19 pandemic, the samples after 2020 for regression. The results are shown in column 2 of Table 5.

Table 5: Robustness Test

	(1)	(2)
VARIABLES	Mfg	Mfg
L.Dig	0.632***	
	(14.453)	
Dig		0.675***
		(14.797)
LnGDP	0.024**	-0.010
	(2.232)	(-0.907)
Gov	0.161***	0.135***
	(5.207)	(4.809)
Ind	0.068**	0.053**
	(2.370)	(2.063)
LnRoad	0.028***	0.019***
	(4.286)	(2.838)
Constant	-0.213*	0.141
	(-1.861)	(1.279)

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Table 5: (continued).

Observations	330	270
R-squared	0.863	0.872
Province	Yes	Yes
Year	Yes	Yes
F	214.2	216.9

Note: T-values are values enclosed in parenthesis. Significance levels at 1%, 5%, and 10% are denoted by ***, **, and *.

From the results in Table 5, the findings pass the robustness tests. The findings of both studies confirm that the digital economy has a positive effect on manufacturing development. In column 1, the lagged digital economy's (L.Dig) coefficient is 0.632, which is positively significant at the 1% significance level, indicating a significant positive lag effect of digital economy on manufacturing development. This suggests that the development of the digital economy can predict the trend of manufacturing development. In Column 2, excluding data after 2020 that may have been impacted by the pandemic, digital economy’s (Dig) coefficient is 0.675, which is still positively significant at the 1% significance level, proving that digital economy plays an important role in promoting manufacturing development in normal economic cycles. These findings support the model's external validity and robustness by showing that the expansion of digital economy consistently aligns with positive growth in the manufacturing across diverse economic contexts.

4. Conclusion

The impact of the digital economy on the development of manufacturing is examined in this article using data from 30 Chinese provinces and municipalities between 2011 and 2022. This paper conducts empirical analysis by constructing a comprehensive indicator system and a panel data model. The growth of the digital economy plays a substantial role in supporting the enhancement of the manufacturing industry based on the findings. In other words, digital advancements have a positive impact on the sector's development. Specifically, enhanced digital infrastructure facilitates intelligent industrial upgrading and informatization construction. The increase in the number of informatization enterprises and the increase in industry revenue are beneficial for production management and resource allocation, which can promote refined management during the manufacturing process. These factors play an important role in improving the quality and efficiency of manufacturing. Meanwhile, the optimization of technical elites and knowledge environments, especially the improvement of technological innovation, are key factors for manufacturing development. Technological innovation not only requires financial investment but also requires high-quality technical elites for research and development. These findings theoretically and practically support the deeper integration of digital technologies and real economy, especially facilitating manufacturing development.

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