



Digital Economy Enabling High-Quality Manufacturing Development: Evidence from Chinese Provincial Data

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Abstract. Shifting growth drivers and optimizing the economic structure is the only way to achieve high-quality development of China's manufacturing sector. The digital economy can effectively improve the level of innovation and the efficiency of resource allocation, which is theoretically beneficial to enabling high-quality development of manufacturing industry. An empirical is conducted based on China's inter-provincial panel data from 2013 to 2020. The findings demonstrate that the development of digital economy can significantly promote the high-quality development of manufacturing industry, and the influence is more prominent in the economically developed regions. Besides, the results of mediation test show that digital economy can indirectly drive the high-quality development of manufacturing industry not only through the independent intermediary path of innovation effect and resource allocative efficiency, but also the chain intermediary channel of "innovation effect -- resource allocative efficiency".

Keywords: Digital economy · Manufacturing · Innovation effect · Resource allocation efficiency · Mediation effect

1 Introduction

Chinese economic growth is in the critical period of economic transition, as the pillar of the national economy, the core of the real economy, the manufacturing industry continues to affect the economic development of our country. Although China has a perfect industrial system and strong market advantages, the contradiction that our manufacturing industry is large but not strong still exists (Zhou et al, 2022) [25]. The problems such as insufficient investment in research and development, the control of core technology by others, and low production efficiency are restricting the high-quality development of manufacturing industry. The report of the 19th National Congress of the CPC pointed out that we should "accelerate the development of advanced manufacturing, promote the deep integration of the Internet, big data, artificial intelligence and the real economy", and the outline of the 14th Five-Year Plan (2021-2025) also clearly put forward the implementation of the strategy of making China stronger in manufacturing. Data show that the total scale of China's digital economy reached 39.2 trillion yuan in 2020, accounting for 38.6% of GDP, and maintained a high growth rate of 9.7%. It can be seen

that digital economy has become a key driving force for economic growth in the new era. In this context, adhering to the strategy of manufacturing power and accelerating the digital transformation of manufacturing industry are the only way to achieve high-quality economic development (Hui and Yang, 2022) [8]. Therefore, it is of great theoretical and practical significance to reveal the interaction mechanism between digital economy and high-quality development of manufacturing industry to promote the healthy development of digital economy and innovation-driven high-quality development of manufacturing industry.

The existing research on digital economy and high-quality economic development is mainly carried out from theoretical and empirical dimensions. From the theoretical perspective, some scholars have demonstrated the internal mechanism of digital economy in promoting enterprise transformation and upgrading (Zhang, Yang and Lv, 2022) and value chain climbing (Folasade, 2020) [5, 23], leading industrial transformation (Liu et al., 2022), optimizing resource allocation (Qian, Liu and Pan, 2022) [12, 13], and thus promoting high-quality economic development from micro, meso and macro perspectives. From the empirical perspective, most scholars, based on the high-quality development of regional economy, have discussed how digital economy promotes high-quality development from the dimensions of production, life, and ecology (Zhou and He, 2020) [24]. Some scholars have also analyzed the realization path of digital economy acting on high-quality economic development from the perspectives of industrial structure (Liu et al., 2022) [12], innovation capability (Ding et al., 2021) and environmental regulation (Wang and Zhang, 2022) [3, 17].

As a core part of the real economy, manufacturing is the key to achieving high-quality economic development. In terms of issues related to the development of digital economy and manufacturing industry, foreign researchers have studied from the perspectives of digital transformation of manufacturing industry (Sven et al., 2020) and new opportunities brought by digital technology (Daniela, 2018) [1, 15]. Some also believe that digital economy can lead to the improvement of manufacturing value chain by reducing costs (GOLDFARB and TUCKER, 2019) and improving services (SZALAVETZ, 2020) [6, 16]. Based on the realistic background of the transformation of old and new drivers, domestic scholars have also launched a heated discussion on the development of digital economy and manufacturing industry. Most scholars have explored the upgrading of manufacturing industry from the perspective of influencing factors (Zhu, 2022) [26]. At the same time, digital economy can also promote the upgrading of manufacturing structure by reducing factor mismatch and improving innovation efficiency, resource allocation efficiency and production efficiency (Du and Jiang, 2022, Li and Wang, 2021) [4, 11]. Some scholars have investigated the relationship between digital economy and high-quality development of manufacturing industry from the perspectives of global value chain (Wu, Lu and Wang, 2022) and industrial integration (Wu and Zhang, 2021) [18, 19].

Most existing analyses shows that digital economy can promote economic growth from all levels, but there are relatively few studies focusing on how digital economy affects the high-quality development of manufacturing industry, and there is no empirical evidence to support it. In this paper we intend to carry out research from the following

three aspects. On the basis of previous research, we first sort out the theoretical framework of high-quality development of digital economy enabling manufacturing industry. Second, we construct a benchmark model using the panel data of 30 provinces (municipalities) in China to test the mechanism of digital economy enabling the high-quality development of manufacturing industry and analyze whether there is regional heterogeneity. Third, the mediation effect model is adopted to further explore the specific realization path of digital economy on the high-quality development of manufacturing industry from the perspectives of innovation effect and resource allocation efficiency.

2 Theoretical Mechanism and Research Hypothesis

2.1 Digital Economy Enables the Direct Mechanism of Action of High-Quality Manufacturing Development

Relying on the Internet, big data, blockchain and other digital technologies, digital economy enables the real economy from the supply side and the demand side by virtue of the advantages of easy replication, non-exclusivity and non-competitiveness of data elements (JONES and TONETTI, 2020) [9], which improves the transmission efficiency of information between enterprises and both ends of supply and demand, and breaks the boundary between supply and demand. From the production side: First, data, information and digital technology into the manufacturing of high-end elements such as product production, circulation and trade, such as labor, capital can assign primary factors to fusion, in promoting factor supply scale, improve quality, increase elements of collaborative can also improve the quality of products. Second, big data, Internet and other digital technologies can weaken the phenomenon of information asymmetry, reduce retrieval costs, achieve accurate matching of supply and demand, and optimize the efficiency of resource allocation. At the same time, the characteristics of the digital economy, such as networking and collaboration, make it very convenient for enterprises to obtain resources, use factors, identify users and promote products, and improve the efficiency of resource utilization. In the process of the transformation of traditional production factors in the digital economy, the requirements of knowledge-intensive and technology-intensive industries on the quality of labor force increase, which leads to the substitution of capital factors for labor factors and the promotion of complex labor demand, thus bringing about the improvement of production efficiency. Third, in the process of digital economy development, digital technology represented by the Internet has penetrated into all walks of life, leading the manufacturing industry to realize digital transformation, and giving birth to new business forms and models such as intelligent manufacturing, personalized customization and platform coordination, and promoting the advanced process of manufacturing structure (Su, Su and Wang, 2021) [14]. Fourth, the flat trading platform created by digital economy can strengthen the connection between supply and demand, guide the division of labor and cooperation of market subjects. Digital technology has the characteristics of real-time connection, which can optimize the industrial chain structure of manufacturing industry, weaken the location difference, and make the industrial chain more closely connected. From the perspective of demand side, the extensive application of digital technology simultaneously reduces the information retrieval and transaction costs on the consumption side, giving rise to diversified and personalized consumption, thereby promoting the innovation and upgrading of consumption mode

and traditional production mode, and indirectly promoting the high-quality development of manufacturing industry (Lauren et al., 2019) [10].

Due to the vast territory of China, there are significant differences in resource endowment, economic level, industrial basis and other aspects among different regions. The multi-dimensional differences make different regions have different abilities to absorb digital kinetic energy, develop digital industries and promote the digital transformation of manufacturing.

Based on the above analysis, hypothesis 1 is put forward: digital economy plays a significant role in promoting the high-quality development of manufacturing industry and presents regional heterogeneity.

2.2 Digital Economy, Innovation Effect and High-Quality Development of Manufacturing

The upgrading of the manufacturing sector is inseparable from innovation, and the development of the digital economy itself is the result of the improvement of the technological level and innovation capacity of the economy and society. First, as a new non-entity production factor, data has the advantages of low cost and high marginal output, which can reduce production costs and promote enterprises to increase investment in innovation and R&D. The innovation mode of enterprises changes from closed to open relying on the digital platform. The digital platform reduces the collaboration cost and communication time of the R&D team, and is conducive to the horizontal and vertical expansion of technical resources, which greatly improves the innovation efficiency. Besides, digital economy improves market transparency, optimizes innovation environment, solves information asymmetry and other problems with the help of platform effect, thus stimulating healthy competition among enterprises. To gain competitive advantages, enterprises carry out innovation in production link, management system, organizational structure and other aspects. At the same time, the development of digital finance has broadened the financing channels of enterprises. Digital technologies such as big data and artificial intelligence have reduced the information asymmetry between enterprises and financial institutions (Diana, Manuel and Ana, 2022) and ensured the diversity of innovative capital sources of enterprises [2]. The digital economy enriches the interaction between supply and demand, helps enterprises accurately identify user needs, promotes the user fit of new products, and thus converts customer value into enterprise value (Xiong, 2022) [20], thus improving the success rate of R&D and innovation.

Based on the above analysis, hypothesis 2 is put forward: digital economy promotes the high-quality development of manufacturing industry through the innovation effect.

2.3 Digital Economy, Efficient Resource Allocation and High-Quality Development of Manufacturing

The digital economy can effectively improve the allocation of factors, mainly reflected in the following three aspects. First of all, digital transformation promotes the optimization of the internal management mode of enterprises, which reduces the inefficiency investment of enterprises and improves the efficiency of internal resource allocation. Secondly, the digital economy flattens the economic organizational structure through

networking and intelligence. On the one hand, the e-commerce platform can achieve accurate product recommendation based on consumption data to expand product consumption demand (Yang and Shen, 2020) and profit space [22]. On the other hand, it makes the enterprise information more transparent, reduces the enterprise information acquisition cost and opportunism from all aspects, and enhances the communication and cooperation between enterprises, so as to realize the rational allocation of resources and promote the high-quality development of manufacturing industry. Finally, the digital economy through industrial convergence effect, industry innovation effect and industry correlation effect to promote manufacturing digital transformation and upgrading of industrial structure, the fusion of digital technology and traditional industry brought momentum to the development of the manufacturing resources in the process of industrial structure transformation to repackage allocation, prompting enterprises production efficiency change from low to high.

Based on the above analysis, hypothesis 3 is put forward: digital economy promotes the high-quality development of manufacturing industry by improving the efficiency of resource allocation.

3 Study Design

3.1 Model Building

First, based on theoretical analysis, the following benchmark regression model is constructed to test the promoting effect of digital economy on the high-quality development of manufacturing industry:

$$MHQ_{it} = \alpha + \beta DIG_{it} + \gamma X_{it} + \varepsilon_{it} \quad (1)$$

Second, to further explore whether innovation level and resource allocation capacity plays a mediating role in this process, a mediating effect model is constructed by referring to the research of Xu et al. (2014) as follows [21]:

$$MHQ_{it} = \alpha_0 + \alpha_1 DIG_{it} + \alpha_2 X_{it} + \varepsilon_{it} \quad (2)$$

$$MV_{it} = \beta_0 + \beta_1 DIG_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (3)$$

$$MHQ_{it} = \gamma_0 + \gamma_1 MV_{it} + \gamma_2 DIG_{it} + \gamma_3 X_{it} + \varepsilon_{it} \quad (4)$$

where MHQ is the high-quality development index of manufacturing industry, DIG is the digital economy index, MV is the intermediary variable, including innovation level (INNO) and resource allocation capacity (ALLO), X_{it} is the set of relevant control variables, i is the province individual, t is the time, ε_{it} is the random disturbance term. The mediation model verification process is as follows:

Step 1, if α_1 is significant, it means that the comprehensive effect exists and can be tested in the next step.

Step 2, if β_1 and γ_1 are significant, there is a mediating effect. If any of the coefficients is not significant, the Sobel statistic is used for the secondary test. If it passes the test, the

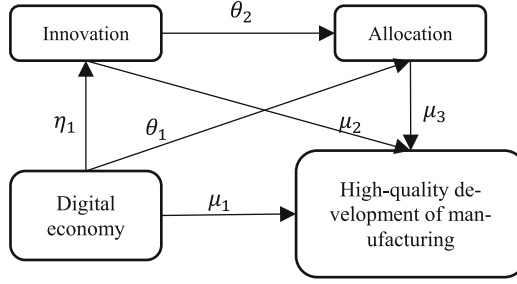


Fig. 1. Path diagram of chained multiple mediating effects

indirect effect is significant, and the third step test is carried out. Otherwise, the indirect effect was not significant and the analysis was stopped.

Step 3, if γ_2 is not significant, it means that the direct effect is not significant and it is a complete mediating effect. If it is significant, that is, the direct effect is significant, the fourth step test will be conducted.

Step 4, the symbols of $\beta_1\gamma_1$ and α_1 are compared. If they are the same, it is part of the mediation effect, and the proportion of the mediation effect in the total effect is $\frac{\beta_1\gamma_1}{\alpha_1}$. Conversely for covering effect, indirect effect and the direct effect than the absolute value of $|\frac{\beta_1\gamma_1}{\alpha_1}|$.

Considering that innovation level may have an impact on resource allocation ability, the chain multiple mediating effect model is adopted to further investigate the mediating channel of high-quality development of digital economy enabling manufacturing industry. The model Settings are shown in Eqs. (5)–(7), and the specific action path is shown in Fig. 1:

$$INNO_{it} = \eta_0 + \eta_1 DIG_{it} + \eta_2 X_{it} + \varepsilon_{it} \quad (5)$$

$$ALLO_{it} = \theta_0 + \theta_1 DIG_{it} + \theta_2 INNO_{it} + \eta_2 X_{it} + \varepsilon_{it} \quad (6)$$

$$MHQ_{it} = \mu_0 + \mu_1 DIG_{it} + \mu_2 INNO_{it} + \mu_3 ALLO_{it} + \eta_2 X_{it} + \varepsilon_{it} \quad (7)$$

where MHQ is the high-quality development index of manufacturing industry, DIG is the digital economy index, INNO is the innovation level, ALLO is the allocation capacity, X_{it} is the set of relevant control variables, i is the province individual, t is the time, ε_{it} is the random disturbance term.

3.2 Variable Selection and Data Sources

Dependent variable: Manufacturing high Quality development (MHQ). The measurement of high-quality development of manufacturing industry in existing studies is mainly divided into two kinds: constructing index system and single index measurement. Referring to the existing literature, this paper selects a total of 11 indicators from the four dimensions of economic benefit, innovation-driven, green manufacturing and social benefit to measure the high-quality development level of manufacturing industry (Table 1), and uses the entropy method to calculate the comprehensive index.

Table 1. Evaluation index system of high-quality development of manufacturing industry.

Target layer	Index layer	Measure	Attribute
Economic benefits	Profit margin	Total profits of industrial Enterprises/ main business income	+
	Productivity of labor	Main business income/ Employment number	+
	International competitiveness	(Export – Import)/ (Export + import)	+
Innovation driven	R&D personnel investment level	The number of R&D personnel invested in industrial enterprises/ Total number of employees employed	+
	Level of R&D investment	The amount of R&D investment/ Main business income of industrial enterprises is regulated	+
	Level of R&D output	Three kinds of domestic patent authorization/Main business income	+
Green manufacturing	Power consumption level	Electricity consumption/ Main business income	–
	Water resource consumption level	Industrial water consumption/ Main business income	–
	Waste water discharge level	Industrial wastewater discharge/ Main business income	–
	Exhaust emission level	SO ₂ emissions/ Main business income	–
Social benefits	Manufacturing wage level	Manufacturing average wage/ Per capita disposable income	+

Core explanatory variable: Digital Economy (DIG). At present, the domestic and foreign academic evaluation index system for the development of digital economy has not formed a unified standard. With the in-depth development of digital economy, in addition to the digital infrastructure and digital industrialization that can be monitored, the potential digital kinetic energy and the integration of digital economy and traditional industries still need to be taken into account. Therefore, this paper refers to the

Table 2. Variable declaration.

Variable types	Variable name	Specific index measurement method	Symbol
Explained variable	High-quality development of manufacturing	High-quality development index of manufacturing industry	MHQ
Explanatory variables	Digital Economy	Digital Economy index	DIG
Intervening variable	Innovation	Number of new product projects of industrial enterprises above designated size	INNO
	Allocation	Government spending/GDP	ALLO
Control variables	Industry scale	Industrial value added/GDP	INS
	Foreign direct investment	Foreign money actually used/GDP	FDI
	Human capital	(Primary school population \times 6+ junior high school population \times 9+ senior high school population \times 12+ junior college and above population \times 16)/total population over 6 years old	HUC
	Level of urbanization	Urban population/total population	URB
	Level of economic development	Regional GDP per capita	AGDP

White Paper of China's Digital Economy Development Index jointly issued by CCID and DeYang, Sichuan Province, from four dimensions: digital infrastructure, information industry development, industrial digitalization development and digital transaction development. Twenty-one indicators such as "cable length", "software industry revenue", "digital finance coverage depth" (Guo et al., 2020) [7], "online mobile payment level" were selected to comprehensively measure the digital economy level of each province, and the entropy method was also used to measure the index.

Mediating variable: Innovation level (INNO). According to the mechanism analysis above, this paper refers to existing literature to measure the innovation level by the number of new product projects of industrial enterprises above scale in the region. Resource allocation capacity (ALLO) is measured by the proportion of government expenditure in GDP. A smaller value of ALLO indicates a lower dependence of enterprises on government regulation and a greater impact of market regulation.

Combined with existing studies, the control variables selected in this paper include: enterprise production cost (INS), foreign direct investment (FDI), human capital (HUC) measured by the average years of education of the population, urbanization level (URB),

Table 3. Descriptive statistics of variables.

Variable	Mean	SD	MIN	MAX
MHQ	0.3652	0.1097	0.1620	0.6805
DIG	0.1250	0.1185	0.0088	0.7287
INN	8.8201	1.4357	4.9095	12.0206
GOV	0.2550	0.1035	0.1188	0.6430
INS	9.8547	1.0649	7.1695	11.8062
FDI	0.0197	0.0183	0.0001	0.1210
HUC	2.2236	0.0914	2.0114	2.5401
URB	0.6031	0.1158	0.3789	0.8960
AGDP	10.9107	0.4119	10.0399	12.0130

and economic development level (AGDP). The specific calculation formula is shown in Table 2. To avoid the influence caused by exchange rate changes, the foreign direct investment is converted into RMB based on the average exchange rate of RMB against US dollar in that year.

This paper selected panel data of 30 provinces and cities in China (excluding Tibet, Hong Kong, Macao and Taiwan) from 2013 to 2020. The data were obtained from China Statistical Yearbook, China Environmental Statistical Yearbook, China Science and Technology Statistical Yearbook, China Foreign Trade Statistical Yearbook, Guoyan.com database, statistical yearbook and statistical bulletin of each province and city. The digital finance-related index is derived from the Digital Financial Inclusion Index of Peking University, and the missing data of some provinces are supplemented by interpolation method. To reduce heteroscedasticity, the indicators (INS, HUC, and INN) that were not proportional were taken as natural logarithms. Descriptive statistics of each variable are shown in Table 3.

4 Empirical Analysis

4.1 Baseline Regression Analysis

The fixed-effect model was selected in this paper according to the results of Hausman test. To test the robustness of the core explanatory variables, regression analysis was conducted by gradually adding control variables. Table 4 reports the regression results of the benchmark model for the digital economy enabling high-quality development of manufacturing.

In Table 4, all models pass the joint significance test, and the regression coefficient of the core explanatory variable is always significantly positive at the level of 1%, indicating that the digital economy has a significant and stable impact on the high-quality development of manufacturing industry. By comparing R^2 of all the models, it can be seen that the explanatory ability of the model gradually increases with the addition of control variables, indicating that the selection of control variables is reasonable to a certain extent.

Table 4. Benchmark regression: The digital economy enables high-quality development of manufacturing.

Variable	MHQ					
	(1)	(2)	(3)	(4)	(5)	(6)
DIG	0.671*** (8.92)	0.674*** (8.08)	0.667*** (8.32)	0.605*** (7.46)	0.472*** (7.21)	0.390*** (7.39)
INS		0.060*** (2.92)	0.053*** (2.61)	0.053*** (2.56)	0.048*** (2.44)	0.023 (1.14)
FDI			0.427*** (2.09)	0.461* (1.86)	0.456* (2.17)	0.453** (2.21)
HUC				0.291** (2.71)	0.001 (0.00)	−0.058 (−0.61)
URB					0.499*** (4.77)	0.245 (1.69)
AGDP						0.092*** (3.03)
cons_	0.279*** (28.94)	−0.312 (−1.72)	−0.251 (−1.26)	−0.888** (−2.66)	−0.482* (−1.96)	−0.947*** (−3.30)
R ²	0.6742	0.7109	0.7235	0.7368	0.7898	0.8083
N	240	240	240	240	240	240

Note: The estimated *t*-values of the corresponding coefficients are shown in parentheses in the table. Standard errors are in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level.

By observing model (6), it can be seen that the coefficient of the core explanatory variable is 0.390. When other conditions remain unchanged, the quality development level of manufacturing industry increases by 0.39% for every 1% increase in the level of digital economy, indicating that digital economy can promote the high-quality development of manufacturing industry and preliminarily verifying hypothesis 1.

4.2 Endogeneity Analysis

Although the above regression results show that the digital economy has a positive impact on the high-quality development of the manufacturing industry, the OLS regression model does not take into account the potential endogeneity problem, resulting in biased model estimation. There are two possible reasons for the endogeneity of this paper. On the one hand, there is a bidirectional causality between the high-quality development of manufacturing industry and the development of digital economy. Manufacturing is an important part of economic development, and the development of manufacturing industry can not only improve the construction of digital infrastructure, but also attract more digital industries. On the other hand, digital economy enables economic growth, which is a gradual process, and the influence brought by digital infrastructure and digital industry

is persistent. Therefore, the digital economy may have a lag effect on the development of manufacturing industry. Although the above analysis controls the relevant variables affecting the high-quality development of manufacturing industry, there may still be omissions. Therefore, this paper chooses the two-way fixed effects model for analysis and adopts the method of introducing instrumental variables to solve the endogeneity problem.

First, referring to the practice of most scholars, the interaction term between the number of fixed phones per 100 people of each province in 1984 and the number of Internet broadband access ports in the previous year was selected as the instrumental variable of digital economy for 2SLS regression (Hainan Province was established in 1988, so it should be excluded for the endogeneity test of this instrumental variable). On the one hand, the number of fixed telephone users in history does not have a great direct impact on the high-quality development of the current manufacturing industry. On the other hand, the number of Internet broadband access ports in the lag period is closely related to the development of the current digital economy, so the selection of this instrumental variable meets the principle of correlation and exogeneity (Ding et al., 2021) [3]. The regression results are shown in Model (1) in Table 5. Second, the lag period of digital economy development level is used as an instrumental variable to conduct 2SLS regression, and the results are shown in model (2) in Table 5.

According to the regression results in Table 5, the P-values of K-P rk LM statistics of the two instrumental variables are all less than 0.01, indicating that there is no problem of insufficient identification. The K-P rk Wald F statistics are all greater than the critical value at the 10% level of Stock-Yogo weak identification test, indicating that there is no weak instrumental variable problem, indicating that the selection of the two instrumental variables is reasonable to a certain extent. The test results of the two instrumental variables show that the benchmark regression results still hold after the endogeneity problem is overcome, that is, hypothesis 1 above is robust.

4.3 Subregional Inspection

Different regions are different in resource endowment, economic foundation and industrial development level, and the impact of digital economy on the high-quality development of manufacturing industry is also different. To further explore the regional heterogeneity of digital economy on the high-quality development of manufacturing industry, this paper refers to the practice of Hui and Yang (2022) [8]. The 30 provinces and cities were divided into two samples: relatively developed areas including Beijing, Tianjin, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Hubei and Chongqing, and relatively undeveloped areas including other provinces for regression analysis. The test results are shown in Model (1) and Model (2) in Table 6, respectively.

The Table 6 shows that the level of economic development of different regions, the development of economy and for manufacturing high quality digital promoting effect were significantly, but from the point of the core variable coefficient, the coefficient of digital economy in the economic developed areas is bigger, show effects on manufacturing high quality development of digital economy exists regional heterogeneity, again to verify the hypothesis 1. The possible reason is that, in economically developed areas, digital economy development in a leading level, the construction of infrastructure to

Table 5. Endogeneity test results.

Variable	MHQ	
	(1)	(2)
DIG	0.422*** (6.31)	0.475*** (8.72)
X	YES	YES
cons	−1.335*** (−3.96)	−1.310*** (−3.99)
Province FE	YES	YES
Year FE	YES	YES
K-P rk LM	24.789 [0.0000]	11.968 [0.0005]
K-P rk Wald F	83.137 {16.38}	520.880 {16.38}
N	201	210

Note: Standard errors are in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; Values in () are robust standard errors; [] is P value; The value in { } is the critical value at the 10 percent level of Stock-Yogo test.

be more perfect, digital economy through integration innovation to realize the digital transformation of manufacturing industry and value chain reconstruction, mature industry system can effectively improve the production efficiency and quality, achieving high quality development. In economy is relatively underdeveloped regions, most provinces are still in the digital economy start-up phase, the innovation ability insufficiency, the infrastructure system is not sound and labor resource shortages, make digital economy failed to deeply integrated with manufacturing, industry development is not a virtuous circle, so a smaller role in promoting the digital economy.

4.4 Mechanism of Action Analysis

4.4.1 Mediating Effect Test of Single Variable

Table 7 reports the test results of the mediating effect of the single variable of the two mediating variables, to test the mediating effect of innovation level and resource allocation efficiency in the above influencing mechanism, Model (1) is the overall impact of the digital economy on the high-quality development of manufacturing industry, which is consistent with the regression results of model (6) in Table 4. By comparing model (1) and model (3), it can be seen that the regression coefficient of digital economy on the high-quality development of manufacturing industry decreases from 0.390 to 0.328 after the intermediary variable of innovation level is added, and the regression coefficient of digital economy in model (2) is significantly positive, indicating that digital economy has

Table 6. Test results of the digital economy enabling high-quality development of manufacturing in the subregion.

Variable	MHQ	
	(1)	(2)
DIG	0.362*** (5.34)	0.314** (2.53)
X	YES	YES
cons	−1.252*** (−4.39)	−1.225*** (−4.35)
R ²	0.9005	0.7448
N	80	160

Note: The estimated *t*-values of the corresponding coefficients are shown in parentheses in the table. Standard errors are in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level.

a promoting effect on the improvement of innovation level. The regression coefficient of innovation level in model (3) is also significantly positive, indicating that the mediating effect of innovation level is valid. Through Sobel-Goodman test, the mediating effect of innovation level is established, and the proportion of mediating effect in the total effect is 15.97%, which verifies the hypothesis 2 proposed above. In terms of the mediating effect size, the direct effect of digital economy empowerment is greater than the mediating effect, indicating that the impact of digital economy on the high-quality development of manufacturing industry is mainly direct empowerment.

Models (4) and (5) report the test results of the mediating effect of resource allocation efficiency. The regression coefficient of digital economy in model (4) is significantly positive, indicating that digital economy has a positive impact on resource allocation efficiency. In model (5), the regression coefficient of resource allocation efficiency on the high-quality development of manufacturing industry is significantly negative. Compared with model (1) and model (5), it can be seen that after adding the mediating variable of resource allocation efficiency, the influence coefficient of digital economy on the high-quality development of manufacturing industry increases from 0.390 to 0.425. Through the Sobel-Goodman test, the mediation effect exists, and the absolute value of indirect effect accounts for 8.98% of the total effect, which is also a hiding effect. It can be interpreted that the digital economy can promote the high-quality development of manufacturing industry by improving the efficiency of enterprise resource allocation, which verifies hypothesis 3. Possible reason is that as the new driving force of the development of the economy, the government needs to invest more funds to promote the development of digital economy, but as the digital economy has gradually become the main power source of stable economic growth, enterprise need not through the government's regulation and control means to expand reproduction, instead will depend more on the market to allocate resources, We will encourage enterprises to constantly

Table 7. Test of mediating effect: The digital economy enables high-quality development of manufacturing.

Variable	MHQ (1)	INNO (2)	MHQ (3)	ALLO (4)	MHQ (5)
INNO	—	—	0.029*** (4.35)	—	—
ALLO	—	—	—	—	−0.625 (−3.26)
DIG	0.390*** (9.78)	2.151*** (5.34)	0.328*** (8.03)	0.132*** (3.94)	0.425*** (10.51)
X	YES	YES	YES	YES	YES
cons_	−0.928*** (−0.240)	0.847 (0.35)	−0.953*** (−4.14)	1.235*** (6.12)	−1.601** (−2.36)
Sobel	—	Z=3.374***, the mediating effect was significant, and the mediating effect accounted for 15.97%		Z=−2.511***, indirect effect was significant, and the proportion of indirect effect was −8.98%	
Adj-R ²	0.9617	0.9773	0.9648	0.9696	0.9635
N	240	240	240	240	240

Note: The estimated *t*-values of the corresponding coefficients are shown in parentheses in the table. Standard errors are in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level.

adapt to market changes and demands, thus forcing the transformation and upgrading of the manufacturing sector.

4.4.2 Chained Multiple Mediating Effect Test

To investigate whether there is mutual influence between the two mediating variables of innovation level and resource allocation efficiency, this paper uses the chain multiple mediating effect model for further analysis, and the regression results are shown in Table 8.

Model (1) in Table 8 takes innovation level as the explained variable, which is consistent with the regression results of model (2) in Table 7. In model (2), resource allocation efficiency was taken as the explained variable, and the regression coefficient of digital economy was significantly positive and the regression coefficient of innovation level was significantly negative, both of which passed the significance test of 1%, indicating that digital economy was conducive to the improvement of resource allocation efficiency, while innovation level had a significant negative impact on resource allocation efficiency. In model (3), the regression coefficients of digital economy, innovation effect and resource allocation efficiency all passed the significance test with the high-quality development of manufacturing industry as the explained variable, and the coefficient of digital economy was 0.361, which was lower than 0.390 in the benchmark regression

Table 8. Results of chained multiple mediating effects test.

Variable	INNO (1)	ALLO (2)	MHQ (3)
DIG	2.151*** (5.84)	0.177*** (3.63)	0.361*** (6.87)
INNO	—	−0.021*** (−2.84)	0.025*** (3.14)
ALLO	—	—	−0.191** (−2.61)
X	YES	YES	YES
cons	2.005 (0.82)	1.427*** (3.57)	−0.734*** (−2.95)
R ²	0.5923	0.4973	0.8293
N	240	240	240

Note: The estimated *t*-values of the corresponding coefficients are shown in parentheses in the table. Standard errors are in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level.

model. This indicates that digital economy can not only promote the high-quality development of manufacturing industry through a single mediation path affecting innovation effect and resource allocation efficiency, but also enable the high-quality development of manufacturing industry through the chain mediation path of “innovation effect -- resource allocation efficiency”.

5 Conclusions

This paper focus on the digital economy and manufacturing high quality development and mechanism of action, the relationship between the theory developed from the viewpoints of both production and consumption analysis. From the point of production, digital economy through assignment of fusion can improve the quality factors of manufacturing and product supply, through the assignment of technology can assign and platform can reduce the enterprise research and development costs and operating costs, improve the allocation of resources efficiency and production efficiency. From the point of consumption, the development of digital technology and the rise of digital platforms strengthen the positive feedback between supply and demand, which can promote the innovation and upgrading of production mode and the improvement of innovation efficiency of manufacturing enterprises. Based on the above analysis, this paper uses the inter-provincial panel data from 2013 to 2020 to build a benchmark regression model and a mediating effect model. From the perspectives of innovation effect and resource allocation efficiency, this paper explores the enabling relationship and action mechanism

between digital economy and high-quality development of manufacturing industry, and draws the following two conclusions:

1. The development of digital economy can significantly improve the level of high-quality development of manufacturing industry. The direction of digital economy on high-quality development of manufacturing industry is the same in different regions, but the intensity of the effect is different.
2. Digital economy can not only promote the high-quality development of manufacturing industry through the innovation effect and improve the efficiency of resource allocation, but also enable the high-quality development of manufacturing industry through the chain mediation effect channel of “innovation effect – resource allocation efficiency”.

Based on the research conclusion, combined with the development status of digital economy and manufacturing industry, the following countermeasures and suggestions are put forward:

First, we should seize the opportunities of the development of the digital economy, give full play to the empowering role of digital technologies, and encourage research, development and innovation. Local governments should accelerate the establishment of industry-university-research cooperation platforms, accelerate the transformation of innovation achievements, guide the deep integration of the digital economy with traditional manufacturing, and promote the digital transformation of manufacturing. In addition to increasing the investment in technological innovation, more attention should be paid to the cultivation of innovative talents, using the digital platform to innovate education methods, expand skills training, and cultivate compound talents with digital literacy.

Second, make full use of the Internet platform to improve the efficiency of resource allocation and optimize the industrial structure. We will adhere to the regulation mode combining government and market, use digital platforms to promote the integration of resources and information of upstream and downstream enterprises in the industrial chain, plan the layout of technology-intensive and knowledge-intensive industries led by the digital economy, eliminate backward production capacity, and promote the advanced and rational development of the industrial structure of the manufacturing industry.

Third, different regions should recognize their own level of industrial development and formulate reasonable digital development strategies according to local conditions. In view of the regional heterogeneity of the enabling effect of digital economy, it is necessary to increase the investment in the construction of digital infrastructure in relatively undeveloped regions, so as to lay a solid technological and material foundation for the development of manufacturing industry. The relatively developed regions should focus on technology-driven industrial development, enrich the application of digital technology, and strengthen the leading role of digital economy in manufacturing industry. At the same time, through government and market regulation means, guide regional cooperation and exchange, accelerate the bridge of the “digital divide” between regions.

Fourth, improve the digital economy regulatory system, improve the data property rights system, and regulate the order of market competition. To speed up the cultivation of data factor market and give play to the enthusiasm and creativity of market subjects, the key lies in the overall formulation of data property rights system, factor circulation

and trading system, the systematic improvement of data factor allocation mechanism and income distribution mechanism, and the construction of a cooperative governance mode of government, market and society. At the same time, it is also necessary to further strengthen the construction of data information base, strengthen the use of technical tools, and coordinate the cooperation of different subjects to promote orderly governance.

Limited by the digital economy measurement method is not mature, the empirical analysis of this paper still has shortcomings. First, the statistical index system of digital economy needs to be improved, which limits the reliability of empirical analysis results to a certain extent. Second, this paper only investigates from the perspective of innovation level and resource allocation. However, the impact of digital economy on manufacturing industry is multifaceted, and more relevant factors can be considered for further analysis in the future.

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