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The Impact Study of the Convergence of the Digital Economy and Manufacturing on Manufacturing Performance

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Abstract

Against the backdrop of the rapid development of the digital economy, digital technologies have extensively penetrated and been applied across various industrial sectors, exhibiting a trend of mutual integration. Utilizing data from the China Input-Output Tables published by the OECD, this study computes the forward and reverse integration indicators for the digital economy industry and the manufacturing industry, analyzing the degree of integra-tion between them. Furthermore, employing dynamic panel data models based on data from 2008 to 2018 across 15 sub-sectors of the manufacturing industry, this research employs the Generalized Method of Moments (GMM) for estimation to investigate the impact of forward and reverse integration on manufacturing industry performance. Empirical results suggest that the initial stages of both forward and reverse integration between the digital economy industry and manufacturing may temporarily adversely affect performance, but in the long run, they exhibit positive effects on manufacturing industry performance. This finding provides empir-ical support for a deeper understanding of the relationship between the digital economy and the manufacturing industry.

Keywords

Digital Economy; Industry Integration; Manufacturing Industry; Industry Performance.

1. Introduction

Amidst the robust development and widespread integration of the new generation of digital tech nologies across various industries, the Chinese government has successively introduced policy proposals to promote the development of the digital economy. These initiatives aim to expedite the convergence of the digital economy with traditional industries, explore new points of economic growth, enhance the quality and level of national economic development, and bolster overall national competitiveness. In the 2017 government work report, the imperative to "promote the accelerated growth of the digital economy" was articulated for the first time. In October 2021, General Secretary Xi Jinping, presiding over the 34th collective study session on the healthy development of China's digital economy, emphasized the need to "promote the integrated development of the digital economy and the real economy, leveraging the amplifying, overlapping, and multiplicative effects of digital technology on economic development." During the 2022 National People's Congress, "the deep integration of digital technology and the real economy" once again became a focal point. Industrial integration has emerged as a critical factor for adjusting industrial structures in the era of the digital economy. Currently, manufacturing stands as one of the most crucial components of the real economy. The rapid development of the new generation of digital technologies has elevated manufacturing to a pivotal domain for digital economic development. Consequently, the gradual convergence of traditional manufacturing and the digital economy industry has become a key element of

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regional development's core competitiveness. Against the backdrop of industrial integration, a proper understanding of the intrinsic laws of industrial convergence is essential for effectively addressing the challenges it presents and formulating scientifically sound policies. This paper primarily focuses on the following core questions: How does the integration of the digital economy and manufacturing affect the performance of the manufacturing industry? In this process, does the application of digital technologies play a positively catalyzing role in aspects such as production efficiency? In-depth research into these questions contributes to providing scientific theoretical guidance and practical insights for the digital transformation of manufacturing. This study comprehensively analyzes the impact mechanism of the integration of the digital economy and manufacturing on manufacturing performance from both theoretical and practical perspectives. It aims to guide the manufacturing industry in better adapting to the developmental trends of the digital era. Moreover, through an in-depth examination of the integration of the digital economy and manufacturing, it can offer insights for policy formulation and industrial planning, facilitating the advancement of China's manufacturing industry toward a higher level of digital transformation. The digital economy, as a pivotal component of the contemporary economy, has garnered widespread academic attention. The following summarizes the main viewpoints of domestic and foreign scholars on the research of the digital economy and manufacturing:

(I) Research on the Concept and Characteristics of the Digital Economy

The digital economy, as the dominant force in contemporary economic development, has been extensively studied both domestically and internationally. In terms of conceptual definition, one perspective broadly defines the digital economy as an economic system centered around digital technologies, with a focus on the application of information technology and the realm of digital transformation[1]. Another perspective emphasizes the digital economy's unique position in the information age, asserting that it is a product of the profound integration of information technology and the economy[2]. Regarding the research on the characteristics of the digital economy, both domestic and international studies primarily concentrate on innovation, efficiency, and globality[3],[4],[5],[6]. Additionally, some research places emphasis on the transformation and enhancement of traditional industries brought about by the digital economy[7],[8].

(II) Research on the Relationship between the Digital Economy and Economic Growth

As a driving force in contemporary economic development, the relationship between the digital economy and economic growth has been a focal point of researcher's attention. Regarding the mechanisms of the relationship between the digital economy and economic growth, several viewpoints exist. Firstly, technological innovation in the digital economy is posited to enhance labor productivity, thereby driving overall economic growth[9]. Secondly, the digitized market environment encourages enterprises to continuously innovate, enhancing the overall competitiveness of the economic system[10]. Thirdly, the development of the digital economy promotes the optimization of industrial structure, facilitating more efficient resource allocation and thus fostering economic growth[11]. Most scholars, both domestically and internationally, posit that the development of the digital economy has a positive impact on economic growth[12],[13], as it enhances productivity, promotes innovation and competition, and optimizes economic structure.

(III) Research on the Integration of the Digital Economy and Manufacturing Industry

The integration of the digital economy and the manufacturing industry is a current hot topic in the economic field, and scholars worldwide have conducted in-depth research from various perspectives. This section categorizes the progression of research on the integration of the digital economy and the manufacturing industry based on the main viewpoints. Firstly, from the perspective of technological innovation and production efficiency, it is argued that the

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convergence of the digital economy industry and manufacturing industry propels the enhancement of production efficiency through technological innovation[14]. The widespread application of digital technology, such as big data, the Internet of Things, and cloud computing, significantly benefits the manufacturing industry[15]. Secondly, from the perspective of digital transformation and intelligent manufacturing, in the research on digital transformation, the integration of the digital economy and the manufacturing industry is considered to have a promoting effect on the upgrading of the manufacturing industry[16]. The study emphasizes the profound impact of digital technology on technological innovation in the manufacturing industry. Researchers highlight the driving role of the integration of the digital economy and the manufacturing industry in technological innovation, emphasizing its positive impact on improving production efficiency[17],[18]. Thirdly, from the perspective of economic benefits and sustainable development, it is argued that the integration of the digital economy and the manufacturing industry has a positive impact on the economic benefits, innovation, and sustainable development of enterprises, providing more opportunities for development[19].

The above research findings indicate that domestic and foreign scholars have explored a wide range of topics in the field of the integration of the digital economy and the manufacturing industry. These topics include the essence and characteristics of the digital economy, the mechanisms of the digital economy's impact on economic growth, and the impact of the integration of the digital economy with traditional manufacturing on various aspects such as technological innovation, production efficiency, economic benefits, and sustainable development. Notably, there is a rich body of research on the relationship between digital economic industries and traditional industries, as well as the driving role of digital technology in industrial integration. However, current research in the field of industrial integration faces two main challenges. Firstly, existing literature predominantly focuses on the integration of information technology with traditional industries, with limited research on the integration issues between digital economic industries and traditional manufacturing industries. Secondly, existing literature mainly employs qualitative analysis methods to study the connotations of industrial integration, lacking empirical analysis literature on this issue. Additionally, there is insufficient research on the effects of industrial integration on economic and social aspects. This paper addresses the dual impact of the digital economic industry and manufacturing industry, constructs metrics for this dual impact, and introduces them into empirical analysis, enriching practical empirical research.

2. Organization of the Text

2.1. Connotation and Exegesis of the Concept

Digital Economy: It refers to a new economic model that emerges with the global wave of digitization, incubating and rising in the new round of technological revolution and industrial transformation. It involves economic activities where digitized knowledge and information (data) serve as crucial production factors, modern information networks act as essential carriers, and the effective utilization of information and communication technology serves as a significant driving force for efficiency improvement and economic structure optimization. The National Bureau of Statistics has explicitly defined the basic scope of the digital economy from the perspectives of "digital industrialization" and "industrial digitization."

Industrial Convergence: Viewed from the perspective of industrial evolution, industrial convergence is the pro cess of cross-sectoral and intra-sectoral intersection and permeation, leading to the formation of new industries. The convergence of the digital economy with the manufacturing industry refers to the intersection and permeation of digital technology with traditional manufacturing, wherein the production, management, and service systems of manufacturing are restructured through means such as digitization, networking, and

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intelligentization to enhance efficiency, reduce costs, and create new value. This convergence not only involves the introduction of digital technology into the manufacturing process but also encompasses the comprehensive digitization of various aspects of the entire industry chain, including design, production, supply chain, sales, and services. Key technologies in this convergence include the Internet of Things, big data analytics, artificial intelligence, cloud computing, and others. These technologies enable the manufacturing industry to better acquire and utilize data, achieve intelligent and flexible production processes, enhance the quality of products and services, and promote information sharing and collaborative innovation among enterprises and along the entire industry chain. The convergence of the digital economy with the manufacturing industry aims to break down the barriers of traditional manufacturing, achieve the comprehensive penetration and application of digital technology throughout the industry, and thereby propel the overall industry upgrade and transformation.

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2.2. Mechanisms of Convergence between the Digital Economy and Manufacturing Industry

The convergence between the digital economy and the manufacturing industry is primarily determined by the dynamic mechanisms of industrial convergence, resulting from the interaction of intrinsic laws and external driving forces, as illustrated in Figure 1.

On the production-supply side, factors such as technology, capital, and labor constitute the driving forces behind industrial convergence. This process involves various types of convergence, including technological, market, and business convergence. Notably, technology innovation-driven industrial convergence is the predominant mechanism. Firstly, technology innovation leads to the integration of two distinct technologies in a synergistic manner, known as "technology + technology." This integration, supported by digital technology, significantly enhances manufacturing efficiency. Concurrently, manufacturing processes, business operations, and product forms gradually undergo digitization, ultimately achieving industrial digitization. Secondly, technology innovation can facilitate convergence through the "technology + product" approach, where traditional industries leverage digital technology to present their products in a digitized format, such as industrial Internet technologies. Finally, technology innovation-driven convergence can also form new business models through the "technology + service" approach, offering convenient solutions like intelligent robots and automated vending machines.Market capital-driven industrial convergence is mainly realized through cross-industry mergers, investments, and the extension of the industrial chain. This restructuring affects the existing enterprise architecture, assets, business, and the ecosystem of the industrial chain, promoting convergence in business, technology, and products across different industries.Talent-driven industrial convergence, fundamentally a knowledge and technology-driven convergence, occurs as knowledge and technology move across industries with the mobility of talent. In the era of big data, where data is integrated into the economic value creation process, the mechanism of data-driven industrial convergence lies in data sharing. The low transfer and diffusion costs of data enable enterprises to obtain this production factor at minimal costs, driving the development and convergence of industries. For instance, industrial big data propels the transformation of the manufacturing industry toward smart manufacturing.

On the demand side, technology innovation alters the characteristics of market demand, introducing new demands from consumption, investment, exports, and government purchases, thereby fostering industrial convergence. Government-industry policies can encourage convergence through the regulation of supply and demand. The spillover effects of new technologies result in changes to the cost functions, market sizes, and economic laws of

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enterprises in different industry sectors, leading to internal convergence within the digital economy and its convergence with the manufacturing industry.

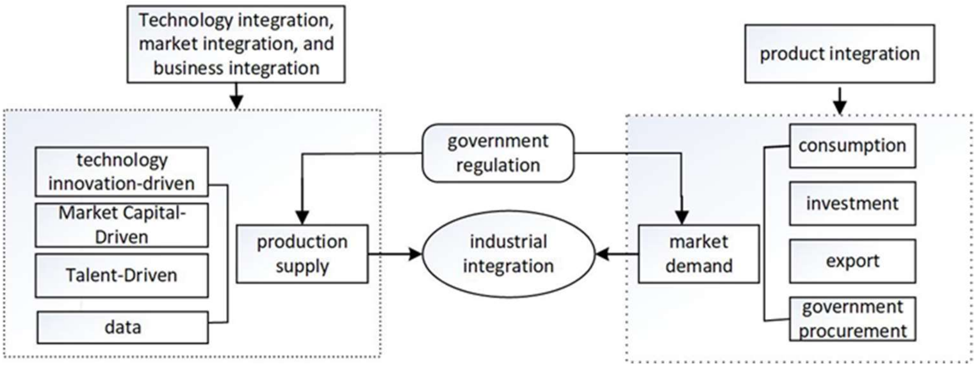

Figure 1. Industrial Integration Mechanism

2.3. The Integration Effects of Digital Economy and Manufacturing Industry

The integration of the digital economy and manufacturing has brought about complex and profound effects, manifesting not only in positive outcomes but also involving a series of potential negative impacts. In terms of positive effects: firstly, there is enhanced resource allocation and efficiency. The integration of the digital economy and manufacturing primarily achieves optimization of resource allocation and efficiency improvement. The digital economy provides tools such as big data analysis, cloud computing, and artificial intelligence, enabling manufacturing to more accurately predict market demands and optimize production plans. This aids in improving the efficiency of the entire supply chain, reducing information asymmetry and coordination issues, thereby avoiding resource wastage and lowering production costs. In this manner, the widespread application of digital technology brings intelligence to the production process, enhancing productivity and ensuring more effective resource utilization[20]. Secondly, there is the construction of a platform-based ecosystem. In the integration path of the digital economy and manufacturing, the rise of industrial platforms is a significant trend. Digital platforms integrate various stages of the supply chain, including design, production, sales, and services, constructing an ecosystem that facilitates closer collaboration among different industries and enterprises. This approach encourages tighter cooperation between upstream and downstream participants in the industrial chain, propelling the overall upgrading of the industry[21]. Thirdly, there is innovation and increased competitiveness. In the integration path of the digital economy and manufacturing, innovation is a key factor driving industrial upgrading. The introduction of digital technology gives rise to new business models, products, and services. Through continuous innovation, the manufacturing industry better adapts to market demands. In this way, the digital economy and manufacturing mutually influence each other, with the digital economy providing innovation impetus, and manufacturing achieving the scale and commercialization of these innovations through more efficient production[22]. Fourthly, there is personalized customization and market adaptability. One of the approaches to the integration of the digital economy and manufacturing is achieving personalized customization. Digital technology allows the manufacturing industry to adjust production lines more flexibly and customize products according to customer demands. This enhances the market adaptability of the manufacturing industry, enabling it to quickly meet diverse requirements and improve market competitiveness[23]. In summary, the industrial integration of the digital economy and manufacturing significantly enhances manufacturing in terms of productivity, personalized customization, innovation, and supply chain collaboration. The digital economy has a positive impact on the digital transformation of manufacturing and its overall performance.

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However, attention must also be paid to negative effects, including the widening digital divide, labor market inequality, and market competition pressure. These dual effects are closely related, requiring us to comprehensively consider how to maximize the positive effects while effectively addressing potential negative impacts. Firstly, there is the issue of imbalanced industrial structural adjustment. The digital transformation driven by the digital economy may lead to an imbalanced adjustment of industrial structure in manufacturing. During the process of digital transformation, some advanced technology and high value-added manufacturing industries may find it easier to digitize, while traditional manufacturing industries may face difficulties in transformation. This may result in internal structural imbalances within the manufacturing industry, increasing the risk of industrial hollowing in some regions or enterprises, thereby affecting the sustainable development of the overall economy. Secondly, there is increased inequality in the labor market and higher unemployment risks. With the introduction of digitalization and automation technologies, certain positions in traditional manufacturing industries may be replaced, thereby increasing the risk of unemployment for some workers. The adoption of new technologies may require employees to possess higher skills, leading to inequality in the labor market, as workers with different skill levels may experience varying degrees of impact[24]. Thirdly, there is the widening of the digital divide. The integration of the digital economy may lead to the widening of the digital divide, where some manufacturing enterprises or regions are unable to fully adapt to the technological transformation. This may be due to factors such as investment capacity and technological literacy, preventing some industries from enjoying the productivity improvement and market opportunities brought by the digital economy[25]. Fourthly, there are challenges faced by small and medium-sized enterprises (SMEs) in manufacturing. The integration of the digital economy may have adverse effects on SMEs in manufacturing, as large-scale digital investments and technological transformations may impose a heavy burden on small-scale enterprises. This increases their competitiveness challenges in the market, making it more difficult for some small-scale manufacturers to survive in the wave of digitization[26]. Fifthly, there is the emergence of new market monopolies and competitive pressures. The trends of digitization and platformization may lead to some digital platforms monopolizing the market in manufacturing, weakening the market competitiveness of traditional manufacturers. Since digital platforms usually control vast data and technological resources, once monopolized, this may result in upstream enterprises in the industrial chain being subject to the market dominance of digital platforms[27].

Overall, the integration effects of the digital economy and manufacturing bring about tremendous positive transformations. However, this trend is not without negative consequences. In the process of digital transformation, we cannot ignore potential challenges such as labor market uncertainties and uneven distribution of industrial structure. Therefore, a thorough analysis of both positive and negative impacts is essential, aiding in a more comprehensive evaluation of the holistic effects of the integration of the digital economy and manufacturing on society, the economy, and industrial patterns. This analysis will provide more effective solutions to address potential issues.

3. Empirical Analysis of the Impact of Industrial Integration on Manufacturing Per-formance

3.1. Measurement of the Integration between Digital Economy and Manufacturing In-dustry

At present, the methods for determining the degree of industrial integration mainly include the Herfindahl index, entropy index, patent method, and input-output method. Compared with other measurement methods, the input-output method can measure both technological and

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operational integration of industries, making it more suitable for measuring the industry penetration type of industrial integration. Therefore, this paper uses the integration data calculated from the 2021 OECD-published international input-output table data.The measurement indicators are mainly constructed from two aspects: the penetration of the digital economy industry into traditional manufacturing (positive integration degree) and the impact of traditional manufacturing on the digital economy industry (reverse integration degree). The OECD input-output table involves mainly manufacturing industries, including: food, beverages, and tobacco; textiles, textile products, leather, and footwear; wood and cork products; paper and printing; coke and refined petroleum products; chemicals and chemical products; pharmaceuticals, medicinal chemicals, and botanical products; rubber and plastic products; other non-metallic mineral products; basic metals; fabricated metal products; electrical equipment; machinery and equipment, nec; motor vehicles, trailers, and semi-trailers; other transport equipment; manufacturing n.e.c.; and machinery equipment maintenance and installation.The OECD input-output table involves industries related to the digital economy, mainly: computers, electronic and optical equipment (D26), telecommunications services (D61), and IT and other telecommunications services (D62T63). This paper refers to the construction method proposed by Zhang J, Chen T, 2016[28], and the specific formula is as follows:

$$\text{Positive Convergence Degree} = \frac{\text{The sum of intermediate inputs from digital economy industries to manufacturing industry i}}{\text{Total output of manufacturing industry i}} \tag{1}$$

$$\text{Reverse Fusion Index} = \frac{\text{The sum of intermediate inputs from manufacturing sector i to the digital economy sector}}{\text{Total output of manufacturing sector i}} \tag{2}$$

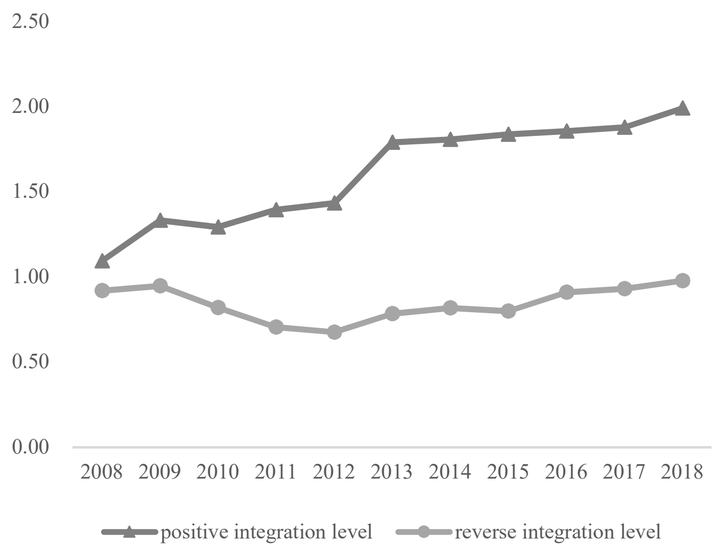

Figure 2. Mean Values of Industry Integration Degrees

Theoretically, a larger positive integration degree indicates a greater investment of the digital economy industry in traditional manufacturing, signifying a more significant penetration effect of the digital economy industry into traditional manufacturing. Conversely, a smaller positive integration degree suggests a smaller impact. A larger reverse integration degree indicates a greater investment of traditional manufacturing in the digital economy industry, implying that

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the integration between the digital economy industry and manufacturing is primarily achieved through the industrial transformation of manufacturing.Figure 2 compares the average positive and reverse integration degrees between the digital economy industry and the manufacturing industry from 2008 to 2018. Two conclusions can be drawn:(1) The positive integration degree shows a gradual increasing trend over time, indicating that the demand for the digital economy industry by the manufacturing industry is increasing year by year.(2) The reverse integration degree exhibited a gradual decline from 2009 to 2012, followed by a slow upward trend from 2013 to 2018. This suggests that with the gradual development of China's digital economy, the utilization and demand of the digital economy industry by the manufacturing industry are gradually increasing.

3.2. Sample Selection and Data Sources

This study utilizes data from the period 2008 to 2018 related to the digital economy in-dustry and manufacturing industry. The data is sourced from the 'International Input-Output Tables' published by OECD in 2021 (covering the years 2009–2019). Data for control varia-bles is primarily derived from the 'China Industrial Economic Statistical Yearbook' (2009-2017) and the 'China Statistical Yearbook' (2009-2019).

3.3. Variable Definitions

(1) Dependent Variable: Manufacturing Industry Performance (Y), measured using the Labor Productivity Comparison method. This method is chosen for its comprehensive assessment compared to other methods. The specific formula is as follows: $Y_i = \frac{G_i/G}{L_i/L}$, Where, Y_i represents manufacturing industry performance, G_i represents the total output value of industry i, G represents the Gross Domestic Product, L_i represents the total labor force of industry i, and L represents the total labor force. A higher calculated value indicates a higher level of industry performance, while a lower value indicates lower performance.

(2) Core explanatory variables: Positive convergence degree between the digital economy industry and manufacturing(PDM), and negative convergence degree between the digital economy industry and manufacturing(RDM). The specific calculation methods are given in equations (1) and (2).

(3) Control variables primarily include the following variables, each chosen for their significant impact on manufacturing performance: Industrial Structure (IDS), Marketization Level (MKL), Market Openness (OPEN), and Industry Scale (ISC).Industrial Structure (IDS) is measured using the average size of enterprises in manufacturing industry i. This indicator is calculated as the ratio of the total output value of manufacturing industry i to the number of enterprises in manufacturing industry i. A higher calculated value indicates a higher degree of market concentration, whereas a lower value suggests lower market concentration.Marketization Level (MKL) is measured by ownership structure. The ownership structure of manufacturing industry i is assessed by the ratio of the total output value of Chinese state-owned enterprises in manufacturing industry i to the total output value of manufacturing industry i. A higher value in this indicator implies a higher proportion of state-owned ownership, leading to lower industrial performance.Market Openness (OPEN) for manufacturing industry i is represented by the ratio of foreign capital to paid-up capital in manufacturing industry i. A higher level of openness in manufacturing industry i indicates a more open market.Industry Scale (ISC) for manufacturing industry i is expressed as the ratio of the output value of manufacturing industry i to the total domestic output value. A larger industry scale is conducive to improving industrial performance.

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3.4. Model Specification

As industrial performance adjustments typically require a certain time frame, the current changes in industrial performance are influenced by past performance. Therefore, this study incorporates lagged industrial performance levels into the model to control for its intrinsic effects. Hence, we establish the following dynamic panel regression model:

$$lnY_{it} = c + \alpha_0 lnY_{it-1} + \alpha_1 lnPDM_{it} + \alpha_2 lnPDM_{it-1} + \alpha_3 lnRDM_{it} + \alpha_4 lnRDM_{it-1} + \alpha_5 lnRDM_{it-2} + \alpha_6 x_{it} + \alpha_7 x_{it-1} + \mu_i + \varepsilon_{it} \quad (3)$$

Where Y_{it} represents industrial performance, Y_{it-1}represents the first-order lag of industrial performance, PDM_{it} represents the positive integration degree of the digital economy industry with the manufacturing industry, and PDM_{it-1} represents the first-order lag of positive integration degree. Similarly, RDM_{it} represents the reverse integration degree of the digital economy industry with the manufacturing industry, while RDM_{it-} , RDM_{it-2} represent the first and second-order lags of the reverse integration degree, respectively. x_{it} represents the control variables, and x_{it-1} represents the first-order lag of the control variables. The specific control variables include: IDS_{it} representing industrial structure, MKL_{it} representing the level of marketization, and $OPEN_{it}$ representing the degree of market openness. Market openness can stimulate industrial development, thereby promoting the improvement of industrial performance. ISC_{it} represents industrial scale, and there is a positive correlation between industrial scale and industrial performance. The expansion of industrial scale will promote the improvement of industrial performance. In the notation, i represents the industry, t represents time, μ_i represents individual effects, and ε_{it} represents the random disturbance term.

3.5. Descriptive Statistical Analysis of Variables

The descriptive statistics presented in Table 1 reveal that the mean value of industrial performance in the manufacturing sector is 15.37, with a maximum value of 63.49, a minimum value of 0.10, and a standard deviation of 11.51. The substantial gap between the maximum and minimum values, coupled with a relatively large standard deviation in comparison to the mean, indicates significant variations in industrial performance across different sectors within manufacturing.The mean values for positive integration degree and reverse integration degree are 0.84 and 1.87, respectively, with standard deviations of 1.02 and 1.70. The maximum values are 4.21 and 6.96, and the minimum values are both 0.11. The notable disparity between the maximum and minimum values, along with a standard deviation relatively larger than the mean, suggests an imbalanced integration of various industries within China's digital economy and manufacturing sectors.In summary, the sample consists of 165 observations, representing a balanced panel dataset. The descriptive statistics underscore the significant diversity in industrial performance and integration levels among different sectors in both China's digital economy and manufacturing landscape.

Table 1. Descriptive Statistical Analysis of Variables

Variable Names	Sample Size	Mean	Std	Min	Max
Y	165	15.37	11.51	0.10	63.49
PDM	165	0.84	1.02	0.11	4.21
RDM	165	1.87	1.70	0.11	6.96
IDS	165	4.37	10.33	0.47	121.5
MKL	164	24.05	29.22	1.17	100
OPEN	165	13.35	6.75	2.88	29.2
ISC	165	6.55	4.69	0.04	20.57

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3.6. Model Estimation and Results Analysis

Table 2. Impact of Industrial Integration on Manufacturing Industry Performance

Variables	(1) dycs_OLS	(2) dycs_FE	(3) dycs_SYS
L.lny	0.963*** (22.37)	0.564*** (7.71)	0.714*** (3.72)
lnpdm	-0.063 (-0.96)	-0.153* (-2.10)	-0.191* (-2.07)
L.lnpdm	0.076 (1.12)	0.164* (1.84)	0.221** (2.33)
lnrdm	-0.012 (-0.21)	-0.055 (-0.90)	0.446 (1.58)
L.lnrdm	-0.048 (-0.53)	0.049 (0.46)	-0.964* (-1.84)
L2.lnrdm	0.059 (1.20)	0.031 (0.63)	0.557* (2.03)
lnids	0.021 (0.31)	0.014 (0.26)	-0.069 (-0.52)
L.lnids	-0.022 (-0.54)	-0.060 (-1.14)	-0.154* (-1.79)
lnopen	-0.337** (-2.26)	-0.364* (-1.84)	-0.571* (-2.08)
L.lnopen	0.305** (2.05)	0.124 (0.71)	0.126 (1.42)
lnisc	1.017*** (52.67)	1.002*** (61.89)	0.968*** (16.25)
L.lnisc	-0.992*** (-51.60)	-0.601*** (-10.08)	-0.825*** (-6.41)
_cons	0.060 (0.61)	1.112* (2.11)	2.465 (1.38)
N	135	135	135
R^2	0.98	0.98	—
p_arm2	—	—	0.876
sargan	—	—	100.935
sar_df	—	—	97.000
sar_p	—	—	0.372

Note: * p<0.1, ** p<0.05, *** p<0.01. The values in parentheses are t-values, where L1 and L2 represent first-order and second-order lag operators, respectively. "—" indicates that the variable is not present in the model.

This paper employs a dynamic panel model to analyze the impact of the integration of the digital economy industry with the manufacturing industry on the industrial performance of the manufacturing industry. This is done to address endogeneity and estimation bias issues present in static panel models. When estimating the panel data model (1), the introduction of lnY_{it-1} may lead to endogeneity problems, and the omission of variables in the model could also cause endogeneity problems, where omitted variables are correlated with industry integration and industrial performance. Therefore, this paper uses the System Generalized Method of Moments (GMM) proposed by Blundell and Bond (1998) to estimate model (1).Firstly, the lagged term of industrial performance is set as an endogenous variable, market openness is set as a predetermined variable, and positive integration and its lagged first order, negative integration and its lagged first and second order, industrial structure and its lagged first order, and industrial scale and its lagged first order are set as exogenous variables. Secondly, considering

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that this study uses small sample data, to ensure the robustness of the estimation results, small sample statistics and a two-step (two-step) System GMM setting are adopted. The results obtained are shown in column (3) of Table 4. In addition, for comparison with the GMM regression results, this study simultaneously estimates using Ordinary Least Squares (OLS) and Fixed Effects (FE) models, and the results are shown in columns (1) to (2) of Table 4.

System GMM requires that instrumental variables must be exogenous variables, and disturbances must not exhibit second-order autocorrelation. To ensure that the model meets the requirements for using System GMM, Sargan instrumental variable validity test and Arellano-Bond serial correlation test are performed. The p-value of the AR(2) test (0.876) is greater than 0.05, indicating that the residuals of the equation significantly reject second-order serial correlation, suggesting that the model does not exhibit second-order serial correlation. The p-value of the Sargan test (0.372) is greater than 0.05, indicating that the null hypothesis of the validity of the instrumental variables is not rejected, meaning that the selected instrumental variables are valid, and there is no over-identification problem in the regression results. In summary, using the System GMM model for estimation is reliable, and thus, column (3) of Table 2 is considered as the main basis for regression analysis.

The regression results in column (3) of Table 2 reveal that the coefficient of current positive fusion degree on the manufacturing industry's industrial performance is -0.191, yielding a significant negative impact. The negative effects may stem from the automation technology replacing traditional jobs, resulting in labor market instability and employment issues, a surge in investment costs, an expanding digital divide, adjustment pressures on enterprise supply chains, mismatched knowledge and skills of employees with digital demands, and an intensification of security and privacy concerns. These factors collectively contribute to the initial adverse effects, requiring companies to cautiously undergo transformation and enhance training to adapt to the development of the digital economy. The regression coefficient of the first-order lag term on the manufacturing industry's industrial performance is 0.221, indicating a significantly positive impact. This suggests that after a certain level of positive fusion degree between the digital economy industry and the manufacturing industry is achieved, it becomes beneficial for enhancing the industrial performance of manufacturing. The coefficient of current reverse fusion degree on the industrial performance of manufacturing is 0.446, producing a positive impact, but it is not statistically significant. The regression coefficient of the first-order lag of the reverse fusion degree on the industrial performance of manufacturing is -0.964, showing a significant negative impact. The coefficient of the second-order lag of the reverse fusion degree on the industrial performance of manufacturing is 0.557, resulting in a significant positive impact. This is mainly due to companies allocating a large amount of funds to the introduction of digital technology and employee training in the initial stage, increasing costs. During the transition period, there might be a decline in production efficiency, labor market instability leading to potential capacity losses. Additionally, the learning curve of digital technology may slow down business operations, affecting the competitiveness of enterprises. Therefore, initial investments may temporarily have adverse effects on performance, but in the long run, adapting to the digital economy can bring more extensive benefits. This can be attributed to the following points: first, the common resources generated during the integration of the digital economy industry and the manufacturing industry can save costs, improve economic efficiency, and promote the input-output efficiency of resources; second, the integration of industries gives rise to a series of new products, increasing the supply of products, and the supply-induced effect creates new demands, which helps improve industrial performance; third, the diffusion of common technologies during the industrial integration process is a key factor triggering the improvement of industrial performance.

Table 4 also provides the OLS and FE estimation results. Although both OLS and FE estimates are biased, they determine the upper and lower bounds of the true estimate of lnY_{it-1}. OLS will

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introduce an upward bias to the coefficient of the first-order lag of the dependent variable, while FE estimation will result in a downward bias. Therefore, the true value of the coefficient of the first-order lag should fall between the OLS and FE estimates (Bond, 2002). As seen from the results in columns (1), (2), and (3) of Table 4, the system GMM estimation results satisfy this requirement.

4. Robustness Tests of the Model

4.1. Robustness Test I: Alternative Measures of Manufacturing Performance

Table 3. The Impact of Industrial Integration on Manufacturing Industry Performance

Variables	(1) dycs_OLS	(2) dycs_FE	(3) dycs_SYS
L.lny	0.970*** (21.54)	0.461*** (7.00)	0.813*** (5.00)
lnpdm	-0.091 (-1.43)	-0.145* (-2.25)	-0.0230 (-0.11)
L.lnpdm	0.106 (1.56)	0.155 (2.01)	0.0430 (0.19)
lnrdm	0.008 (0.16)	-0.0139 (-0.24)	0.104 (0.73)
L.lnrdm	-0.079 (-0.99)	-0.0470 (-0.39)	-0.465 (-1.89)
L2.lnrdm	0.069 (1.54)	0.0932 (1.23)	0.377* (2.82)
lnids	0.022 (0.43)	0.00998 (0.25)	-0.00116 (-0.03)
L.lnids	-0.021 (-0.67)	-0.0394 (-0.91)	-0.0919 (-1.26)
lnopen	-0.254** (-2.23)	-0.276 (-1.86)	-0.287 (-1.81)
L.lnopen	0.242** (2.15)	0.0729 (0.57)	0.0610 (0.70)
lnisc	0.778*** (47.22)	0.767*** (55.27)	0.772*** (21.30)
L.lnisc	-0.775*** (-36.83)	-0.383*** (-6.87)	-0.690*** (-8.84)
_cons	0.0295 (0.33)	1.299* (2.68)	1.261 (1.17)
N	135	135	135
R^2	0.97	0.97	—
p_arm2	—	—	0.480
sargan	—	—	100.71
sar_df	—	—	97
sar_p	—	—	0.378

Note: * p<0.1, ** p<0.05, *** p<0.01. The values in parentheses are t-values, where L1 and L2 represent first-order and second-order lag operators, respectively. "—" indicates that the variable is not present in the model.

In the empirical analysis in the previous sections, manufacturing performance was measured using comparative labor productivity. Here, we employ the total asset contribution rate (the ratio of total profits to the average total assets) to gauge industrial performance. In this section, total asset contribution rate is considered as the measure of industrial performance, and

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regression analysis is conducted to examine the relationship between industrial integration and industrial performance. The specific results are presented in Table 3.

The regression results from Table 3 indicate that when measuring manufacturing industry perfor mance using the total asset contribution rate, the direction of the impact of positive integration and reverse integration on manufacturing industry performance is consistent with the previous analysis. Specifically, positive integration has a negative impact on manufacturing industry performance, with its first-order lag showing a positive influence. On the other hand, reverse integration has a positive impact on manufacturing industry performance, although it is not statistically significant. The first-order lag of reverse integration has a negative but insignificant impact on manufacturing industry performance, while the second-order lag of reverse integration has a significant positive impact. Overall, the relationship between positive integration, reverse integration, and manufacturing industry performance appears to be stable.

4.2. Robustness Test II: Alternative Measures of Control Variables

Table 4. Impact of Industry Integration on Manufacturing Industry Performance

Variables	(1) dycs_OLS	(2) dycs_FE	(3) dycs_SYS
L.lny	0.973*** (23.36)	0.547*** (3.47)	0.819*** (7.76)
lnpdm	-0.056 (-0.89)	-0.094 (-0.99)	-0.170* (-2.10)
L.lnpdm	0.069 (1.07)	0.137 (1.31)	0.173** (2.44)
lnrdm	-0.040 (-1.21)	-0.026 (-0.94)	-0.143* (-2.08)
L.lnrdm	0.030 (0.89)	-0.071 (-1.32)	0.052* (1.65)
lnids	0.020 (0.41)	0.020 (0.44)	-0.001 (-0.02)
L.lnids	-0.020 (-0.49)	-0.017 (-0.72)	-0.054 (-1.50)
lnmkl	0.001 (0.01)	0.017 (0.54)	-0.314 (-1.57)
L.lnmkl	0.007 (0.22)	0.046 (0.98)	0.230 (1.58)
lnisc	1.013*** (43.73)	1.008*** (74.84)	0.951*** (21.01)
L.lnisc	-0.998*** (-56.99)	-0.561*** (-3.26)	-0.825*** (-7.39)
_cons	0.023 (0.43)	0.577 (1.35)	1.181 (1.58)
N	150	150	150
R^2	0.98	0.97	—
p_arm2	—	—	0.439
sargan	—	—	115.03
sar_df	—	—	125
sar_p	—	—	0.728

Note: * p<0.1, ** p<0.05, *** p<0.01. The values in parentheses are t-values, where L1 and L2 represent first-order and second-order lag operators, respectively. "—" indicates that the variable is not present in the model.

From the perspective of model setup, the inclusion of control variables not only enhances the ex planatory power of the model but also further influences the significance and sensitivity of

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the core explanatory variables. Therefore, it becomes an important means of stability testing in empirical research. In this study, the variable "Market Openness" was removed from the regression model, and "Marketization Level" was introduced for GMM estimation. The specific results are presented in Table 4.

The regression results from Table 4 indicate that the direction of the impact of positive and nega tive integration on manufacturing industry performance is consistent with the previous analysis. In summary, the relationship between positive integration, negative integration, and manufacturing industry performance appears to be stable.

5. Conclusion and Recommendations

This study utilizes data from the OECD World Input-Output Tables for China spanning from 2008 to 2018 to calculate the positive and negative integration degrees between the digital economy industry and various sectors within the manufacturing industry. From a two-way integration perspective, the current status and trends of integration between the Chinese digital economy industry and manufacturing industry are examined. The results indicate a gradual increase in positive integration over time, suggesting a growing demand for the digital economy industry from the manufacturing sector. The negative integration shows a slow upward trend from 2013 to 2018, indicating an increasing utilization and demand for the manufacturing industry from the digital economy industry as China's digital economy develops. Moreover, positive integration exceeds negative integration, emphasizing the significant role of the digital economy industry as an intermediate input in the manufacturing production process. The integration between the digital economy industry and the manufacturing industry has been on the rise over the past decade, promoting mutual integration between the two sectors, facilitating progress and development in productivity, transforming traditional industries and technologies, and achieving industrial digitization.

Furthermore, through System Generalized Method of Moments (GMM) estimation, the study examines the impact of positive and negative integration on manufacturing industry performance. The results suggest that the initial positive and negative integration between the digital economy industry and the manufacturing industry may have temporary adverse effects on performance. However, in the long term, both types of integration can have positive effects on manufacturing industry performance. Possible reasons include the cost-saving benefits of common resources generated during the integration process, increased economic efficiency, and improved input-output efficiency. Additionally, the integration process stimulates the development of new products, increasing the supply of products and creating new demand, ultimately enhancing industrial performance. Lastly, the diffusion of common technologies during the integration process proves to be a key factor in boosting industrial performance.

Based on the research findings, the following recommendations are proposed to promote deep integration between the digital economy industry and manufacturing industry, maximizing their potential synergies: 1) Promote research and innovation in digital technology, increase investment in basic research in the digital economy sector, encourage innovation, and establish a policy environment conducive to the development of digital technology to further elevate the digital economy industry. 2) Encourage industrial penetration in the integration process, support the development of new products and new industrial chains in the process of industrial integration, promote deeper cooperation between the digital economy industry and manufacturing industry, and create more development opportunities. 3) Strengthen the organic integration of digital technology and manufacturing, through policy guidance and technical support, promote the organic integration of digital technology into manufacturing, enhance digital production levels, and improve manufacturing industry performance. 4) Establish a cooperative platform, create a collaborative platform for the digital economy industry and manufacturing industry, promote information sharing, technological exchange, and accelerate cooperation in innovation, production, and management. These recommendations collectively aim to facilitate deep integration between the digital economy and manufacturing industry, propel the upgrade and innovation of the Chinese manufacturing industry, and inject new impetus into economic development.

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