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# Pathways for Digital Transformation of Manufacturing and Strategies for Bridging the Digital Divide in the Process of Yangtze River Delta Integration

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**Abstract** Under the dual strategic background of Yangtze River Delta regional integration and digital transformation of manufacturing industry, this paper firstly constructs an evaluation system from the three dimensions of the level of digital economy development, digitalization of manufacturing inputs, and the level of comprehensive transformation, and applies the entropy method and the comprehensive index method to measure the capability of digital transformation of the manufacturing industry of the Yangtze River Delta from 2015 to 2024. Through the panel fixed effect model and mediation effect model to verify the influence mechanism of digital economy on the transformation and upgrading of manufacturing industry, it is found that digital economy promotes the transformation through the dual path of optimizing resource allocation and promoting regional innovation. Benchmark regression shows that the core explanatory variables of digital economy pass the significance test at 1% confidence interval, and the regression coefficients are positive. For every 1-unit increase in the level of digital economy development, the comprehensive score of manufacturing transformation and upgrading increases by 0.298 units. In the mediation effect, the estimated coefficients of the level of digital economy development on different models are 205.47, 0.169, -50.29, 0.627, respectively, which passed the significance test at 1% level. Combined with the results of the study, corresponding transformation paths and digital divide elimination strategies are proposed.

**Index Terms** digital economy, panel fixed effects model, mediated effects model, manufacturing transformation, digital divide

## I. Introduction

Accelerating the digital transformation of the manufacturing industry and improving the level of industrial digitization is one of the key initiatives for seizing the main track of manufacturing competition and realizing the high-quality development of the manufacturing industry in the digital era [1]. Existing studies have fully emphasized the key significance of promoting the digital transformation of the manufacturing industry and have basically confirmed the key impact of digital transformation on the high-quality development of the manufacturing industry and the enhancement of international competitiveness [2], [3]. While accelerating the digital transformation to help the high-quality development of the manufacturing industry, relying on the scientific evaluation system to explore the current status of digital transformation of the manufacturing industry and its relative level is conducive to clarifying the facts of digital transformation of the manufacturing industry of the current economic subjects, grasping the key to the development of the transformation of the industry and the focus of the key, in order to find the key path to continue to promote the digital transformation of the manufacturing industry to a higher level to provide a basis for the digital transformation of the manufacturing industry [4]-[7].

The Yangtze River Delta (YRD) region, with rich human resources, technological innovativeness and market advantages, is an important engine for China's economic development, and while implementing the integrated development strategy, synergy and sharing have become an important means and goal to strengthen regional integration [8], [9]. The Yangtze River Delta is one of the most dynamic and open regions in China's economy, and is also bound to play a key role in the process of digital transformation of China's manufacturing industry [10]. Public data show that the current economic aggregate of the three provinces and one city in the Yangtze River Delta has accounted for nearly 25% of the country's total, with the manufacturing industry accounting for 25.62%, and the science and technology research and development expenditures of industrial enterprises above the large-scale accounting for more than 30%. And the research results on the development of China's digital economy also show that the level of digital economy development in the Yangtze River Delta provinces and cities is among the top in

the country [11]. The clear strategic positioning, good economic foundation, and prerequisites brought about by the rapid development of the digital economy determine the Yangtze River Delta's pioneering position in the process of digital transformation of China's manufacturing industry [12], [13]. While exploring the level of digital transformation of the manufacturing industry in the Yangtze River Delta region and its key features, and designing and exploring the path of sustained improvement of the regional digitalization level, it will not only help to provide reference for the Yangtze River Delta to clarify the current situation of the digital transformation of the manufacturing industry in the region and the road to the future, and to eliminate the digital divide, but also provide the key for China to promote the high-level digital transformation of the manufacturing industry in general, and to clarify the layout of digital transformation in key regions. The reality is based on [14]-[16].

This paper first defines the connotation of industrial digital transformation and constructs an evaluation system for the digital transformation of the manufacturing industry in the Yangtze River Delta. Based on the 2015-2024 data of the Yangtze River Delta, it dynamically measures the evolutionary characteristics of its manufacturing digital transformation capability. Construct a model of the impact of the digital economy on the transformation and upgrading of the manufacturing industry, and test its impact mechanism and indirect impact path through two-way fixed effects and mediation effects. Combined with the robustness test, the reliability of the empirical analysis results is verified. Synthesize the results of dynamic measurement and econometric modeling, and propose the digital transformation strategy of manufacturing industry in Yangtze River Delta.

## II. Design of Digital Transformation Evaluation System for Yangtze River Delta Manufacturing Industry

Against the background of accelerated restructuring of the global industrial competition pattern and deep penetration of digital technology, the digital transformation of the manufacturing industry has become the core driving force for the high-quality development of the regional economy. As one of the regions with the most active economic development, the highest degree of openness and the strongest innovation capacity in China, the effectiveness of digital transformation of the manufacturing industry in the Yangtze River Delta is not only related to the enhancement of the competitiveness of the regional industry, but also has a demonstrative leading role in the transformation and upgrading of China's manufacturing industry. However, affected by the imbalance of regional development, differences in digital infrastructure, uneven digitalization level of enterprises and other factors, the digital transformation of manufacturing industry in the Yangtze River Delta is facing the challenges of “digital divide” and ambiguous transformation path. How to scientifically assess the current situation of digital transformation of the manufacturing industry in the Yangtze River Delta, identify the key influencing factors, and explore the differentiated transformation paths has become a theoretical and practical problem that needs to be solved urgently.

### *II. A.Definition of digital transformation of industries*

In the digital era, research on digital transformation has become more and more abundant, and representative research results have defined the connotation of digitalization of enterprises and economic forms from a micro or macro perspective. Based on the meso perspective, the research on industrial digital transformation has also provided a clear theoretical reference for the definition of the connotation of manufacturing digital transformation. On the one hand, some studies focus on the industrial input-output process, pointing out that the digital transformation of industry is manifested in the effective input and use of digital elements and digital technology in the production process; on the other hand, relevant studies have emphasized the key determining role of the digital economy and the digitalization of the industry's own inputs on its overall digital transformation.

The research in this paper also observes the digital transformation of manufacturing industry in the Yangtze River Delta region from two aspects, namely, the development of regional digital economy and the characteristics of industrial input digitalization. In this regard, based on the existing research, this paper summarizes the connotation of industrial digital transformation development as follows: under the premise of the development of regional digital economy and the continuous optimization of the conditions for digital transformation, the industrial inputs and outputs are effectively integrated with the digital intermediate inputs, and ultimately realize the process of digitally-driven transformation and development.

### *II. B.Evaluation System Design for Digital Transformation of Manufacturing Industry in Yangtze River Delta*

(1) Evaluation design of digital economy development level of provinces and cities. Combined with the aforementioned definition of the connotation of industrial digital transformation, this paper first assesses the level of digital economy development of provinces and cities in the Yangtze River Delta region. To address the issue of digital economy development, this paper combines the characteristics of digital economy development and the

availability of provincial and municipal data to observe and evaluate the level of digital economy development in the Yangtze River Delta from the perspectives of digital infrastructure and digital technology development.

Firstly, we consider the development of digital infrastructure in provinces and cities, and in the process of evaluation, we have included four indicators, namely, telephone penetration rate, local exchange capacity, mobile exchange capacity, and the length of long-distance fiber optic cables, in order to measure the level of facilities for the development of the digital economy in each province and city. Secondly, taking into account the development characteristics of industries and related technologies related to the digital economy, we have included six indicators, namely, the total amount of telecommunication services, the input of personnel in the information transmission, software and information technology service industry, the input of personnel in the electronic and communication equipment manufacturing industry, the income from software business, the income from software products, and the number of digital TV subscribers, in order to reflect the impact of the support of the digital industry and the driving force of the digital technology in the provinces and municipalities. In the evaluation process, this paper also pays attention to the environmental protection of the digital economy development in each province and city, so it includes six indicators, namely, the year-end resident population change volume of the province and city, the education level of the employed (undergraduate), the internal expenditure of R&D funds in the electronic and communication equipment manufacturing industry, the turnover of the provincial and municipal technology market, the number of domestic patent applications authorized in the province and city and the provincial and municipal marketization index, in order to assess the external conditions of support and environmental protection for the development of the digital economy in the provinces and municipalities. The external conditions of support and environmental protection for the development of the digital economy in each province and city are evaluated.

Based on the selection of the above indicators, this paper comprehensively evaluates the level of digital economy development of the provinces and cities in the Yangtze River Delta, taking into account the idea of academics of objectively assigning weights to the indicators based on the entropy method and then carrying out a comprehensive evaluation. The final evaluation result is expressed in $dig_{imt}$, where $i$ indicates a province or city in the Yangtze River Delta, $t$ is the period, and $m$ indicates the three categories of indicators considered in the above evaluation process, which can ultimately measure the comprehensive level of the digital infrastructure, digital industry and technology, and digital economic development environment of the province or city in a certain period of time, and the greater the result of the indicator evaluation, the higher the level of digital economic development of the province or city.

(2) Evaluation design of manufacturing input digitization level. The digitalization of manufacturing inputs reflects the degree of contribution of digital intermediate elements in the process of industrial input and output, which is also one of the key considerations in the evaluation of the digital transformation of the manufacturing industry. This paper refers to the idea of measuring the relative consumption coefficient and then measuring the relative contribution of intermediate inputs in the process of industrial output to measure the level of manufacturing input digitization. First, the direct consumption coefficient of all intermediate inputs in the manufacturing output process of provinces and cities is calculated:

$$a_{ijkt} = x_{ijkt} / y_{ijt} \tag{1}$$

In the formula (1), subscripts $i$, $j$, $k$, respectively, indicate the provinces and cities, manufacturing industries and intermediate input categories, $a_{ijkt}$ indicates $t$ period $i$ provinces and cities $j$ manufacturing industry on intermediate inputs $k$ direct consumption coefficients, $x_{ijkt}$ for the $t$ period of $i$ provinces and cities $j$ manufacturing output process $k$ the total amount of intermediate inputs, $y_{ijt}$ for the $t$ period of $i$ provinces and cities in the manufacturing industry $j$ the total output. The direct consumption coefficients of intermediate inputs in the digital sector in the manufacturing output process are further calculated:

$$a_{ijd} = x_{ijd} / y_{ijd}, d \in k \tag{2}$$

In equation (2), the subscript $d$ indicates the intermediate inputs from the digital sector among all intermediate inputs, and $a_{ijd}$ is the direct consumption coefficient of the manufacturing sector to the intermediate inputs $d$ from the digital sector in the $t$ period $i$ provinces and cities.

On this basis, the relative consumption coefficient of the manufacturing sector to the digital intermediate inputs $d$ is calculated for the $t$ period $j$:

$$digi_{ijdt} = a_{ijd} \Big/ \sum\nolimits_k a_{ijkt}, d \in k \tag{3}$$

Equation (3) calculated $digi_{ijdt}$ that is $t$ period $i$ provinces and cities $j$ manufacturing industry's own input digitization level, $digi_{ijdt}$ the larger the measurement results, indicating that the manufacturing industry input digitization level is also higher.

(3) Provincial and municipal manufacturing digital transformation evaluation design. The above measurement process design evaluates the development of digital economy and the input digitalization level of manufacturing industry in each province and city in the Yangtze River Delta, based on which, this paper measures the final digital transformation level of manufacturing industry in each province and city:

$$digt_{ijt} = \sum_m \sum_d dig_{imt} \cdot digi_{ijdt} \tag{4}$$

Formula (4) the final calculation of $digt_{ijt}$ that is $t$ period $i$ provinces and cities $j$ manufacturing industry final digital transformation level, the greater the results of the index calculation, indicating that the level of digital transformation of the manufacturing industry in the province and city is also higher. Equation (4) calculation process, when $j$ represents the manufacturing industry as a whole or a specific industry, this paper can calculate the overall manufacturing industry in the provinces and cities or sub-industry digital transformation level; when $d$ for all or a category of digital intermediate inputs, this paper can be calculated in the provinces and cities as a whole or a category of digital intermediate inputs (or a certain type of inputs digitization) to support the level of digital transformation of the industry.

## III. Measurement and Evaluation of Digital Transformation Capability of Manufacturing Industry in Yangtze River Delta

The research data mainly comes from 2015-2024 China Statistical Yearbook, the Yangtze River Delta Regional Statistical Yearbook (covering Shanghai, Jiangsu, Zhejiang and Anhui provinces and cities), annual statistical bulletins of provinces and cities, public databases of the National Bureau of Statistics and local statistical bureaus, and some of the micro-indicators are referred to the China Industrial Statistical Yearbook, the China Science and Technology Statistical Yearbook, and the report on the development of digital transformation of the manufacturing industry issued by the Ministry of Industry and Information Technology, etc.

### *III. A. Dynamic measurement*

The digital transformation capability of the manufacturing industry in the Yangtze River Delta (YRD) is measured, resulting in the dynamic assessment of the digital transformation capability of the manufacturing industry in the YRD from 2015 to 2024, as shown in Table 1. Table 1 covers the comprehensive score and the four major sub-indicators of high-endization, intelligence, greening, and integration, with each score reaching 75.018, 70.271, 78.017, 46.082, and 76.093 respectively by 2024.

Table 1: Dynamic Assessment Results of Digital Transformation Capabilities

| Year | Comprehensive score | High-end development | Intelligence | Greening | Integration |
|---|---|---|---|---|---|
| 2015 | 19.362 | 25.974 | 5.087 | 64.153 | 2.864 |
| 2016 | 21.636 | 30.083 | 23.825 | 53.927 | 4.926 |
| 2017 | 26.059 | 24.221 | 40.028 | 41.902 | 14.027 |
| 2018 | 22.117 | 29.285 | 26.735 | 37.937 | 16.118 |
| 2019 | 40.184 | 60.297 | 33.079 | 33.186 | 28.047 |
| 2020 | 43.296 | 62.118 | 39.117 | 28.024 | 45.114 |
| 2021 | 61.038 | 57.286 | 62.048 | 39.226 | 90.486 |
| 2022 | 66.227 | 62.024 | 70.186 | 40.375 | 69.355 |
| 2023 | 70.219 | 67.118 | 74.229 | 43.286 | 72.864 |
| 2024 | 75.018 | 70.271 | 78.017 | 46.082 | 76.093 |

### *III. B. Measurement of changes in overall dynamics*

The overall trend of the digital transformation capability of the manufacturing industry in the Yangtze River Delta from 2015 to 2024 can be derived from Table 1, and its visualization results are shown in Figure 1. As can be seen from Figure 1, the digital transformation capability of the manufacturing industry in the Yangtze River Delta is gradually improving in general.After 2018, the digital transformation capability of the manufacturing industry in the Yangtze River Delta has entered a stage of rapid improvement.The main reason may be on the one hand, the demonstration role played by the remarkable results achieved by the digital economy, as well as China's further attention to the research and development of core technology and the cultivation of digital talents, etc., after the

outbreak of the trade war between China and the U.S. in 2018. On the other hand, the digital economy surged and developed rapidly during the prevention and control of the new crown epidemic, leading to the digital transformation of industries. It should be noted that changes in China's external situation have led to the continued increase in the triple pressure of demand contraction, supply shocks, and expectations turn, and the economic growth rate of the Yangtze River Delta in 2021 has also declined, nevertheless, the comprehensive evaluation score of the digital transformation capacity of the manufacturing industry in the Yangtze River Delta in 2024 (75.018 points) is still significantly better than that of the 2020 comprehensive evaluation score (43.296 points).

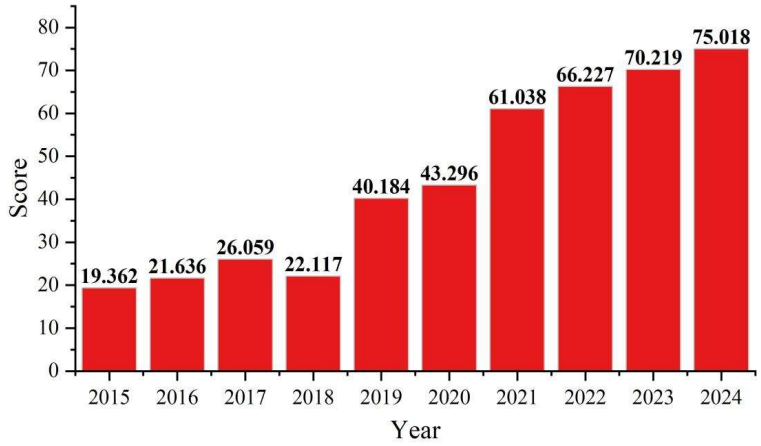


Figure 1: Overall change trend of digital transformation capabilities

### *III. C. Measurement of structural dynamic changes*

From Table 1, the year-to-year dynamics of each sub-capability in the digital transformation capability of the manufacturing industry in the Yangtze River Delta can be depicted as shown in Figure 2. It can be seen that the overall trend of high-end digital transformation capability of the manufacturing industry in the Yangtze River Delta shows a smooth enhancement. The scoring value rises from 25.974 in 2015 to 70.271 in 2024.The intelligent digital transformation capability is increasing, and the leap in scoring value from 5.087 to 78.017 from 2015 to 2022 is realized, which is related to the promulgation and implementation of a series of national policies and plans, and the vigorous development of intelligent manufacturing. The greening digital transformation capability shows a clear downward trend and is slow to recover, with the rating value falling from 64.153 in 2015 to 46.082 in 2024. Where the rating value even drops to 28.024 in 2020, with a gradual recovery thereafter. The ability to integrate digital transformation has improved significantly, with a rating of 2.864 in 2015, and has steadily improved since then, reaching 90.486 in 2021, and 76.093 in 2024, although the rating has declined. The possible reason is that since 2020 under the strict prevention and control of the new crown epidemic the digital economy has surged, and new industries, new forms of business and new business models have continued to emerge, greatly improving the level of manufacturing convergence.

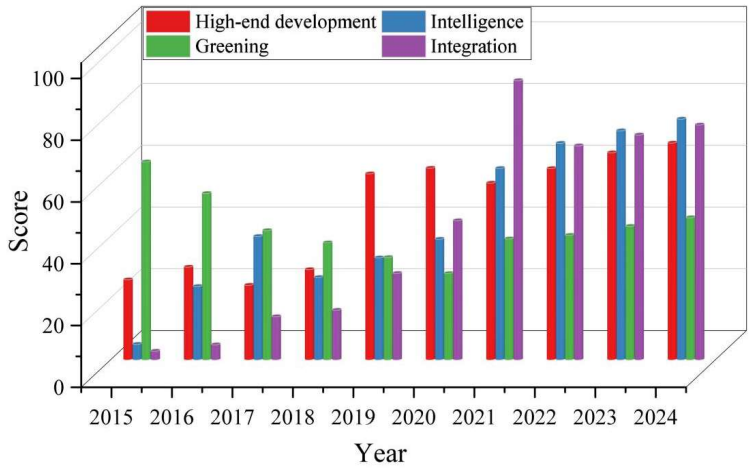


Figure 2: Dynamic Changes in the structure of digital transformation capabilities

# IV. Analysis of the Impact of Digital Economy on the Transformation and Upgrading of Manufacturing Industry in the Yangtze River Delta

## *IV. A. Variable selection and descriptive statistics*

(1) Explained variables

The core explanatory variable of this paper is the transformation and upgrading of manufacturing industry (Upi), which is developed from the four dimensions of high-end, intelligent, green and integration of manufacturing industry.

(2) Explanatory variables

The core explanatory variable of this paper is the level of digital economy development (Dig).

(3) Other control variables

a) Foreign direct investment (FDI): capital, advanced technology and other elements brought by the introduction of FDI in a region will all affect the structure within industries and the linkage between industries in many ways, thus promoting industrial upgrading, so it is necessary to use it as a control variable. In this paper, the amount of foreign direct investment is expressed by the proportion of total foreign investment in each region to GDP.

b) Technology input (SC): The technology input in this paper is calculated by the proportion of R&D internal expenditure in GDP in each region, whether it is the level of digital economy development or the level of transformation and upgrading of the manufacturing industry is inseparable from the investment of science and technology, technology investment can promote the output of related technology innovation by improving the level of basic research, applied research and experimental development, and improve the level of transformation and upgrading of the manufacturing industry.

c) The degree of government participation (GP): In this paper, the degree of government participation is expressed by the proportion of local financial expenditure in the general budget to GDP, and the government's support or intervention in the development of the whole industry will have a significant impact on its transformation and upgrading.

(4) Mediating variables

For the selection of mediating variables, this paper explores the existence of mediating effects in terms of resource allocation and regional innovation. In terms of resource allocation, this paper selects the year-end loan balance of financial institutions in each region as the proxy variable for capital factor allocation capacity $(K)$. In terms of regional innovation, this paper selects the number of patent applications in each region as a proxy variable for regional innovation capacity $(RI)$.

## *IV. B. Modeling*

(1) Panel fixed effects model

The following model is constructed according to the transmission mechanism of the digital economy affecting the transformation and upgrading of the manufacturing industry:

$$Up_{it} = \alpha_0 + \alpha_1 Dig_{it} + \alpha_2 X_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{5}$$

Where: $Dig_{it}$ is the level of digital economy development in a province in a certain period, $Up_{it}$ is the level of manufacturing transformation and upgrading in a province in a certain period, $X_{it}$ is a series of control variables, $\alpha_0$ is the intercept term, $\alpha_1$ is the regression coefficient of the digital economy on the transformation and upgrading of the manufacturing industry, $\mu_i$ is the individual fixed effect, $\delta_t$ is the time fixed effect, and $\varepsilon_{it}$ is the random disturbance term.

(2) Mediating effect model

The mediating effect model is chosen to test the intrinsic mechanism of the digital economy's impact on the transformation and upgrading of the manufacturing industry. The mediating variables $H_{it}$ chosen in this part are: resource allocation (K), regional innovation (RI), combined with the baseline regression equation (5), and set up equations (6) to (7) as follows:

$$H_{it} = \beta_0 + \beta_1 Dig_{it} + \beta_2 X_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{6}$$

$$Up_{it} = \gamma_0 + \gamma_1 Dig_{it} + \gamma_2 H_{it} + \gamma_3 X_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{7}$$

Among them, equation (6) reflects the linear regression equation of the level of digital economy development $(Dig_{it})$ and mediating variable $(H_{it})$; equation (7) reflects the linear regression equation of the level of digital economy development $(Dig_{it})$ and the mediating effect of mediating variable $(H_{it})$ on the transformation and upgrading of the manufacturing industry $(Up_{it})$.

### *IV. C. Analysis of results*

#### IV. C. 1) Benchmark regression results

First of all, in order to test the impact of the digital economy on the transformation and upgrading of the manufacturing industry, according to the Hausmann test to select a two-way fixed-effects model to regress the equation (5), and list the random-effects model and the fixed-effects model for comparative analysis, the model regression results are shown in Table 2. Where t-values are in parentheses, and “***”, “**” and “*” denote the significance levels of 1%, 5% and 10%, respectively. The core explanatory variables of digital economy pass the significance test at 1% level confidence interval, and the regression coefficients are positive, indicating that the digital economy has a significant and facilitating effect on the transformation of China's manufacturing industry.

Among the control variables, the coefficient of foreign direct investment (FDI) is positive and passes the significance test at the 1% level, indicating that the introduction of foreign capital positively promotes the transformation of the manufacturing industry through the effect of technological spillover and industrial chain upgrading. The coefficient of technical investment (SC) is negative and fails the significance test, probably due to the lagging short-term benefits of R&D investment or the difference in the efficiency of R&D resource allocation between regions. The coefficient of government participation (GP) is positive and passes the significance test at the 1% level, reflecting the guiding role of local governments in the transformation of the manufacturing industry through financial subsidies, tax incentives and other policies. The direction of the coefficients of the random effects model and the fixed effects model is the same, and the $R^2$ of the fixed effects model (0.283) is significantly higher than that of the random effects model (0.169), which verifies the applicability of the two-way fixed effects model. In addition, the joint significance test (F-test) of the control variables rejected the original hypothesis ($p<0.01$), indicating that the model setting is reasonable and the explanatory power of the digital economy on the transformation and upgrading of the manufacturing industry is strong.

Table 2: Benchmark Regression Results

| | Random Effects Model<br>Up | Individual fixed model<br>Up | Bidirectional Fixed Effect Model<br>Up |
|---|---|---|---|
| Dig | 0.601*** | 0.302*** | 0.298*** |
| | (0.0397) | (0.0683) | (0.0705) |
| FDI | 0.0946*** | 0.0738*** | 0.0885*** |
| | (0.0205) | (0.0205) | (0.0217) |
| SC | 0.846 | -2.563** | -1.496 |
| | (0.957) | (0.994) | (1.387) |
| GP | -0.0286** | 0.137*** | 0.0838*** |
| | (0.0186) | (0.0302) | (0.0311) |
| Constant | 0.501*** | -0.937*** | -0.602 |
| | (0.125) | (0.311) | (0.367) |
| Observations | 500 | 500 | 500 |
| Number of id | 50 | 50 | 50 |
| R-squared | 0.0846 | 0.169 | 0.283 |

#### IV. C. 2) Analysis of intermediation effects

In this part, the mediation effect model is chosen to test the intrinsic mechanism, and the results of the mediation effect test are shown in Table 3. Columns (1) and (2) of Table 3 are used to test the effect of the digital economy on the transformation and upgrading of the manufacturing industry when resource allocation is used as a mediating variable, and columns (3) and (4) are used to test the effect of the digital economy on the transformation and upgrading of the manufacturing industry when regional innovation is used as a mediating variable. It can be seen that the estimated coefficients of the level of digital economy development on different models are 205.47, 0.169, -50.29, and 0.627 respectively, which passed the significance test at 1% level.

The regression coefficient of digital economy in column (1) is significantly positive, indicating that digital economy promotes resource allocation enhancement. The regression coefficients of digital economy and resource allocation in column (2) are significantly positive, indicating that the enhancement of resource allocation has a facilitating effect on the transformation and upgrading of the manufacturing industry, and the synthesis of columns (1) and (2) reveals that the development of the digital economy can affect the transformation and upgrading of the manufacturing industry through the promotion of the enhancement of resource allocation. When regional innovation is used as a mediator, the coefficient of the direct effect of digital economy on regional innovation is -50.29 (1% significant), the

coefficient of the indirect effect of regional innovation on transformation is -0.00287 (1% significant), and the total effect is 0.627 (1% significant), which indicates that while the digital economy enhances the regional innovation capacity, there may be a time lag effect of innovation incentives and transformation of the results, which leads to a direct effect is negative but the indirect effect is significant. From a comprehensive point of view, the impact of the digital economy on the transformation and upgrading of the manufacturing industry is dominated by direct effects, and resource allocation and regional innovation play an intermediary role through the dual paths of factor optimization and innovation drive, respectively.

Table 3: Results of the mediating effect test

| | (1)<br>Up | (2)<br>Up | (3)<br>Up | (4)<br>Up |
|---|---|---|---|---|
| Dig | 205.47*** | 0.169*** | -50.29*** | 0.627*** |
| | (60.35) | (0.0822) | (-4.79) | (-20.58) |
| K | - | 0.000386*** | - | - |
| | - | (9.04e-05) | - | - |
| RI | - | - | - | -0.00287*** |
| | - | - | - | (-6.04) |
| FDI | -1,957 | -1.224 | -10.386 | 0.119*** |
| | (1,295) | (1.646) | (-1.273) | (6.035) |
| SC | 15.473 | 0.0894*** | -903.66*** | 6.284*** |
| | (20.11) | (0.0385) | (-5.07) | (8.81) |
| GP | -160.35** | 0.158** | 9.567* | -0.0347** |
| | (50.58) | (0.0947) | (-2.56) | (-2.95) |
| Constant | -500.28* | -0.532 | -119.68** | 0.526** |
| | (244.63) | (0.442) | (-2.69) | (-3.01) |
| Observations | 500 | 500 | 500 | 500 |
| Number of id | 50 | 50 | 50 | 50 |
| R-squared | 0.3028 | 0.3386 | 0.4797 | 0.5012 |

**IV. C. 3) Robustness Tests**

In order to further confirm the possibility that the level of the digital economy can have a contributing effect on the high quality development of the manufacturing industry, a robustness test is conducted. Tobit model (model 8), least squares (model 9), y lagged one period for regression (model 10) were used for the robustness test. The results of the robustness test are shown in Table 4, the Dig in the model all pass the 1% significance level and the coefficients are all positive, indicating that the results of the above empirical analysis are robust and reliable.

Table 4: Results of robustness tests

| Variable | Model 8 | Model 9 | Model 10 |
|---|---|---|---|
| Dig | 0.801*** | 0.823*** | 0.849*** |
| FDI | 0.033*** | 0.032*** | 0.046** |
| SC | -0.011 | -0.205*** | 0.012 |
| GP | -0.009 | 0.012 | 0.004 |
| K | 0.028*** | 0.011 | 0.009 |
| RI | -0.012 | 0.000 | 0.031 |
| Constant | -0.093 | 0.156*** | -0.178 |
| Observations | 500 | 500 | 500 |
| Number of id | 50 | - | 50 |
| R-squared | - | 0.911 | 0.702 |

## V. Conclusions and Strategies

### *V. A. Conclusion*

(1) The overall digital transformation capability of the manufacturing industry in the Yangtze River Delta shows a continuous improvement trend, but with significant structural differentiation. 2015-2024 composite score jumps from 19.362 to 75.018, with a significant growth in the levels of high-end, intelligence and integration, but the greening

index drops from 64.153 to 46.082 (the lowest is 28.024 in 2020), reflecting the greening transition lags behind other dimensions.

(2) The digital economy is the core driving force for the transformation and upgrading of the manufacturing industry, and plays a role through a dual mediation mechanism. Benchmark regression shows that the core explanatory variables of the digital economy have passed the significance test under the 1% level confidence interval, and the regression coefficient is positive. For every 1 unit increase in the level of digital economy development, the comprehensive score of manufacturing transformation and upgrading increases by 0.298 units. The mediation effect test confirms that the digital economy indirectly promotes transformation by optimizing capital factor allocation and promoting regional innovation. The estimated coefficients of digital economy development level on different models are 205.47, 0.169, -50.29 and 0.627 respectively, which passed the significance test at 1% level.

### *V. B. Strategies*

(1) Scientific and technological innovation to lead and promote the transformation and upgrading: As China's independent innovation capability is not strong, the digital transformation and upgrading of manufacturing industry needs to greatly strengthen the degree of research and development of core science and technology in manufacturing industry. On the one hand, we can not let the traditional industries in the upgrade of short board, emerging industries to cultivate the development of a soft underbelly, on the other hand, the only have their own independent brand and technology in order to stand in the world manufacturing industry in the competitive market of long-term development, invincible.

(2) Build an innovation ecosystem to realize mutual benefit and coexistence: take intelligent manufacturing and green digital technology as the core to break through the bottleneck of transformation technology. In response to the advantages of intelligentization, relying on the Shanghai Industrial Internet Platform and Jiangsu Suzhou Industrial Software Cluster, we will focus on supporting the landing of digital twins and flexible manufacturing scenarios in advantageous industries such as automobiles and electronic information. In response to the shortcomings of greening, accelerate the deployment of energy management digital systems, and promote the synergistic innovation of digital technology and energy-saving carbon reduction technology.

(3) Narrowing the technological divide, bridging the resource divide, and easing the application divide: In response to the problem of weak digital infrastructure in some counties in Anhui and Zhejiang, increase financial transfer payments, and prioritize the layout of 5G base stations and edge computing centers in areas such as northern Anhui and southwestern Zhejiang. Establish a cross-regional resource allocation mechanism to guide the flow of digital technology resources from the Yangtze River Delta to less developed regions. Implementing a categorized transformation policy, encouraging large enterprises to take the lead in formulating industry digital transformation standards and exporting solutions. Promote lightweight digitalization tools for small and medium-sized enterprises to lower the threshold of transformation.

(4) The government actively guides and improves the policy system: In the process of developing the manufacturing industry, the government actively guides the development of the manufacturing industry the government is very important in the development of the manufacturing industry. The government strongly supports and guides the industry and industrial development cannot be separated from the driving force of the market. In order to accelerate the pace to realize the digital transformation and upgrading of the manufacturing industry, the government plays a role that can not be ignored. The government plays a good guiding role, in addition to being able to create many development opportunities for the manufacturing industry, but also can provide a good infrastructure, capital channels and other good external environment for enterprises.

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