

# Research on the Mechanism of Digital Empowerment for the Integrated and Symbiotic Development of Industry and Towns

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## Abstract

Addressing the long-standing structural disconnection issues of “having towns without industries” and “having industries without towns” at the township level in China, and in the context of the in-depth promotion of China’s digital rural strategy, this study, based on panel data from 1508 counties in China from 2018 to 2020, systematically reveals the empowering mechanism of digital technology on the integration of industries and towns through fixed-effects models and dual machine learning causality tests. The empirical results indicate that digital technology promotes coordinated urban-rural development by significantly enhancing the level of industry-town integration. The main pathways of its impact rely on three mechanisms: residents’ wealth accumulation, labor factor return, and expansion of external demand markets. Furthermore, the empowering effect of digital technology exhibits a pronounced “pro-poor” characteristic, with a significantly stronger impact in key poverty-stricken counties compared to non-poverty-stricken counties, and a higher promotional effect in regions with lower resident income compared to higher income regions. This finding provides micro-level evidence for the digital economy driving common prosperity.

## Keywords

Digital Empowerment, Integration of Industry and Township, Symbiotic Development

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## 1. Introduction

Against the backdrop of rapid technological transformation, addressing regional development disparities and promoting inclusive economic growth remain persistent global challenges (Deng et al., 2023). In pursuing the global goals of balanced development and shared prosperity, the effective integration of urban and rural areas has become a key pathway (He et al., 2024). Townships play a crucial bridging role in this process. They can effectively bridge spatial divides and unlock the synergistic potential of industries and settlements, serving as the core foundation for driving sustainable and equitable development.

Digital technology, as the core driving force of the new industrial revolution, offers unprecedented opportunities to reshape spatial development patterns and overcome traditional divides (Özcan Alp & Baycan, 2024; Zhang et al., 2025a). Digital inclusive finance can alleviate credit constraints and stimulate entrepreneurial vitality, particularly in rural and underdeveloped areas (Jiang, 2024; Wei et al., 2025). Similarly, smart agriculture technologies are optimizing agricultural systems (Alahe et al., 2024; Et-Taibi et al., 2024). Digital platforms can effectively enhance market connectivity and logistics efficiency (Loonam & O'Regan, 2022), and reduce transaction costs (Deng et al., 2022). However, the effectiveness of digitalization varies by context (Bi, 2024), to fully leverage digital advantages, it is essential to deeply understand how they interact with specific local governance structures, industrial capacity, and service systems. Caution is needed to avoid issues such as prioritizing hardware over local services or interventions that fail to adapt to diverse local needs.

China provides a dynamic and prominent research arena for exploring the integration of industry and regions driven by digitalization, particularly the complex mechanisms at the township level. China faces significant urban-rural disparities (Zhu et al., 2020) and has set goals for regional coordination and common prosperity. It has also vigorously promoted the “Digital Rural Development Strategy” policy. To study how digital technology can specifically address the structural disconnect between townships and industries, and what the resource coordination mechanisms are within and around township areas. This paper proposes to use panel data from the county level in China from 2018 to 2020 to deeply analyze the intrinsic mechanisms of digital empowerment for the symbiotic integration of industries and towns. Through theoretical analysis and empirical research, it aims to reveal the pathways and impact effects of digital technology in this process. The contributions of this study include: first, delving into the underlying mechanisms through which digital technology influences the integration and symbiosis of industries and towns, thereby enriching the theoretical framework; second, employing empirical research methods to accurately assess the actual effects of digital empowerment on industry-town integration, providing scientific basis for policy formulation; and third, examining the differences between poor and non-poor counties and the gradient differences in residents’ income levels, proposing targeted policy recommendations to better leverage digital technology in serving the goals of industry-town integration and common prosperity.

## 2. Literature Review

The concept of “urban-rural integration” originated from the concept of “urbanization”. As early as over 100 years ago, Marx proposed that the history of modernization is the history of rural urbanization. This perspective has been further developed and validated in subsequent research. As urbanization progresses, changes in population mobility and industrial layout will drive economic development and transformation (Zhang et al., 2022). Especially in Asia, the process of urbanization is closely linked to the concept of urban-rural integration, with its development primarily driven by urban-rural integration to advance urbanization (Corte & Viganò, 2022; Gu, 2019), forming a unique regional development path. The theory of industry-town integration is rooted in this academic context, inheriting the core of traditional urbanization theory while applying and extending the concept of “industry-city integration” at the town level, thereby forming the concept of “industry-town integration”.

With the rise of digital technology, the role of digital empowerment in the process of industry-town integration has become increasingly prominent (Batty, 2013; Kwan, 2016). The theoretical framework for digital empowerment in industry-town integration exhibits multi-dimensional drivers. From a mechanism perspective, the digital economy directly drives the process of new-type urbanization through the dual-dimensional reconstruction of “hard infrastructure-soft environment” (Lu et al., 2025); at the material level, it enhances the comprehensive carrying capacity of towns through digital infrastructure (Li et al., 2023) and revitalizes traditional economic vitality through industrial digital transformation (Li et al., 2024); in the governance dimension, it utilizes big data platforms to achieve precise supply of public services and cross-departmental collaborative governance (Chen et al., 2019), driving the modernization of urban governance systems. This enabling effect is more fully realized in eastern regions and urban agglomerations, where the benefits and spillover effects of digital economic development are more fully unleashed. However, the effects of the digital economy’s enabling process are influenced by multiple factors. As a new economic form, the digital economy plays a crucial role in promoting agricultural modernization, accelerating information flow between urban and rural areas, and increasing rural residents’ income, thereby contributing to regional coordination (Chen et al., 2025). However, this inevitably leads to issues such as the widening of the urban-rural digital divide, thereby affecting the extent to which rural residents can effectively benefit from the digital economy (Tao et al., 2024).

A review of existing literature reveals that while some studies have examined the impact of the digital economy on urban-rural integration and town development, there are two key shortcomings in understanding the underlying mechanisms of digital technology-enabled synergy between industry and towns under the goal of common prosperity: First, there is a lack of in-depth analysis of the unique characteristics of “industry-town integration” at the town level, particularly a failure to systematically elucidate how digital technology addresses the

structural contradictions of “towns without industries” and “industries without towns”. Second, heterogeneous analyses are often limited to regional differences between eastern, central, and western China, with insufficient targeted discussions on the enabling differences between poor counties and non-poor counties, as well as between traditional industrial towns and emerging digital towns. Additionally, there is limited attention to the nonlinear regulatory role of digital technology in promoting equitable public services at the town level.

### 3. Theoretical Framework and Hypotheses

With the rapid development of information technology, digital technology has increasingly become a key driver of socio-economic development. Accelerating the digitalization of industries and the integration of digital technologies into traditional industries, while achieving deep integration between urban areas and industries, is an important pathway for the integrated development of urban and rural areas. This approach plays a positive role in promoting economic growth, optimizing industrial structures, advancing urban-rural integration, and enhancing the well-being of the people. Additionally, in the process of integrating industries and towns, digital technologies play a crucial role, particularly in promoting industrial upgrading, enhancing governance efficiency, and strengthening innovation capabilities (Fang & Liu, 2024).

As a new driving force, digital technology can facilitate the transformation of an industrial structure dominated by labor-intensive and heavy industries into one dominated by high-tech and environmentally friendly industries, serving as a key driver for China’s industrial structure to advance toward the mid-to-high end (Ren et al., 2023; Zhang et al., 2025b). The upgrading and transformation of the industrial structure is also an intrinsic driving force for China’s high-quality economic development and an important component of building a modern economic system (Wang & Li, 2024). The widespread adoption of digital technology can accelerate industrial connectivity, foster emerging industries, and drive the optimization and upgrading of the industrial structure. Additionally, by leveraging digital technology to upgrade traditional industries, it is possible to achieve intelligent, green, and high-end development of industries, significantly enhancing their production efficiency and competitiveness, and further advancing the optimization and upgrading of the industrial structure (Zeng & Yang, 2023). This can also facilitate the deep integration of towns and industries, thereby driving the rapid growth of town-level economies.

Furthermore, digital empowerment can promote integrated urban-rural development. By efficiently applying digital technologies, information barriers between urban and rural areas can be broken down, enabling the effective flow of resources and complementary advantages between urban and rural areas (Bai et al., 2025). The enabling effects of digital technologies not only extend public services to town areas, improving living standards and development levels in these regions, but also enhance governance efficiency (Du et al., 2025). By building smart city and

smart community platforms using digital technology, information sharing and collaborative cooperation among town governments, strong town enterprises, and urban residents can be achieved, thereby improving governance efficiency and precision. Additionally, the application of digital technology helps enhance innovation capabilities (Xue et al., 2024), providing urban residents with a broad space and platform for innovation and entrepreneurship, thereby stimulating their innovative spirit and creativity and driving the innovative development of the town economy. These factors collectively promote the effective allocation of resources and the widespread sharing of benefits, fostering the integrated development of industries and towns, and laying a solid foundation for achieving common prosperity. Based on this, this paper proposes the following hypothesis:

**H1:** Under the backdrop of common prosperity, digital technology can effectively empower the integrated development of industries and towns.

In the process of digital technology-driven integration and symbiosis between industry and town, residents' wealth accumulation, labor factor return, and external demand market expansion constitute a key regulatory system. These three dimensions systematically regulate the intensity and path of the release of digital technology's empowering effects by altering factor allocation efficiency, market responsiveness, and human capital structure. Among them, residents' wealth accumulation provides the necessary economic foundation and social capital for the application of digital technology. According to endogenous growth theory, when residents' wealth levels reach a threshold, their marginal propensity to consume decreases while their willingness to invest increases (Zheng & Liu, 2025).

Digital technology is more likely to form a virtuous cycle of "technology adoption-benefit transformation-reinvestment" in regions with higher wealth levels. On the one hand, wealth accumulation enhances residents' purchasing power for digital devices and willingness to learn digital skills, promoting technology penetration. On the other hand, the demonstration effect generated by wealth stratification stimulates group imitation and innovation, driving the diffusion of digital technology from the production side to the consumption side. Especially in county-level economies, farmers achieve premium sales of agricultural products through e-commerce platforms (Gao et al., 2025), and their capital reinvestment often flows to supporting industries such as cold chain logistics, forming a chain reaction of "wealth accumulation-digital infrastructure improvement-industrial upgrading". Based on this, this paper proposes the following hypothesis:

**H2:** In the context of common prosperity, digital technology can effectively empower the integrated and symbiotic development of industry and town through the effect of increasing residents' income.

With the development of digital technology, the reverse flow of labor has reshaped the distribution of human capital between urban and rural areas. New migration economics has pointed out that the urban technical experience and digital literacy brought by returning labor can effectively fill the human capital gap in rural areas (Ehrenfeld, 2024). When labor return rates are high, the ap-

plication of digital technology exhibits a “dual-drive” characteristic: on the supply side, returning groups act as “digital translators”, reducing the social friction costs associated with the promotion of new technologies; on the demand side, their upgraded consumption preferences drive the digital transformation of local service industries. For example, returning entrepreneurs leverage short video platforms for targeted marketing (Liu et al., 2025), and their successful cases rapidly spread through rural social networks, creating a multiplier effect for technology diffusion. This coupling of human capital and digital technology significantly enhances industrial synergy efficiency, enabling digital empowerment effects to exhibit economies of scale. Based on this, the following hypotheses are proposed:

**H3:** Under the backdrop of common prosperity, digital technology can effectively empower the symbiotic integration of industries and towns through the labor return effect.

The expansion of external demand markets reinforces the innovative incentives of digital technology by altering the structure of factor rewards. According to the theory of dynamic comparative advantage, export-oriented industries accelerate the application of digital technology to maintain competitiveness when facing international competition (Kong et al., 2024). When external demand is strong, the enabling role of digital technology follows a “demand-driven innovation” path: international market quality standards drive the digital transformation of production processes, while cross-border e-commerce platforms optimize supply chain response speeds through real-time data feedback (Yan et al., 2023). For example, after export-oriented agricultural processing enterprises introduced blockchain traceability systems, their enhanced export premium capabilities prompted surrounding supporting industries to digitize simultaneously. This external demand-driven technological iteration has positive externalities, making the promotional role of digital technology in industry-town integration more prominent in regions with high openness. Based on this, this paper proposes the following hypothesis:

**H4:** Under the backdrop of common prosperity, digital technology can effectively empower industry-town integration and symbiosis through the external demand stimulation effect.

## 4. Research Design and Variable Description

### 4.1. Model Specification

To examine the impact of digital technology on the integration of industry and town, this study constructs the following fixed effects model for empirical testing:

$$cp_{i,t} = \beta_0 + \beta_1 de_{i,t} + \beta_c X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Among these,  $cp_{i,t}$  represents the level of industry-town integration in county  $i$  in year  $t$ ;  $de$  represents the level of digitalization in county  $i$  in year  $t$ ;  $X$  represents a series of control variables that may influence industry-town integration;  $\mu_i$

and  $\delta_t$  represent unobservable individual fixed effects and time fixed effects, respectively;  $\varepsilon_{i,t}$  represents the random error term;  $\beta_0$  represents the intercept term of the model;  $\beta_1$  is the coefficient of the digital technology variable, whose magnitude and sign reflect its impact on industry-town integration.

## 4.2. Sample Selection and Data Sources

On the one hand, township industries are rooted in county-level areas through the integrated development of the primary, secondary, and tertiary sectors in rural areas. On the other hand, as the basic administrative units of China's administrative divisions, township units have relatively limited channels for data acquisition, poor stability and continuity of basic data, and significant challenges in obtaining data. Taking into account the difficulty of data acquisition and the rationality of indicators, this study draws on the approach of (Lai et al., 2022) to position the enabling effects of digital technology on the integration of industries and towns at the county level.

Based on this, to investigate the impact of digital technology on the integration of industry and town under the background of common prosperity, this study, after data collation and screening, has collected and organized panel data from a total of 1508 county-level samples in China from 2018 to 2020. The specific data sources include the Digital Village Index of Counties released by the New Rural Development Research Institute of Peking University, the Statistical Yearbook of China's Counties (County and City Volume), the CSMAR database, the annual county-level database of CEIC, and statistical bulletins of various counties and cities. Missing values for some county-level data were supplemented using linear interpolation and by querying annual statistical bulletins and five-year planning data of the missing counties.

## 4.3. Variable Definition

### 4.3.1. Dependent Variable: Town-Industry Integration (cp)

Following the approach of (Lai et al., 2022), this study uses the average DMSP/OLS light intensity across China's counties and districts as a proxy indicator for industry-town integration. The reason is that nighttime light intensity is the most direct and comprehensive visible light representation of the intensity of human economic and social activities in the town area, which can effectively capture the symbiotic relationship between "industry" and "town" in the development process of interdependence and mutual promotion. Continuous and high-intensity light patches are usually highly correlated with industrial clusters such as industrial areas, logistics parks, and large commercial facilities. Their brightness and range changes can reflect the vitality and spatial expansion of industrial development (Gui et al., 2024) as well as the wealth level of the region (Alesina et al., 2016). The essence of industry town integration is the organic combination and collaborative symbiosis of industry and urban functions within a specific region. This symbiotic relationship is manifested as industrial development providing employ-

ment opportunities, economic power, and tax sources for urban areas, driving urban expansion and prosperity; Urban areas provide labor, infrastructure, public services, and market space for industries, supporting industrial upgrading and agglomeration. This high-intensity and close interactive relationship will manifest as abnormally active and intensive human economic activities within the region. And nighttime light intensity is an ideal proxy variable for capturing this high-intensity economic interaction and factor aggregation. In areas with a high degree of integration between industry and town, the “production” (industry) and “life” (urban) activities are highly overlapping and inseparable in terms of time and intensity. Industrial workers gather to form residential areas, which stimulate consumer spending; The service industry in urban areas, in turn, provides services to the industrial population. The highly mixed and interactive “industry city” functions in this area result in a comprehensive lighting intensity that far exceeds that of a single functional area at night, and is more long-lasting and bright. Therefore, the average brightness of the overall lighting in a county can reflect the superposition level and interaction frequency of the economic energy of the two major systems of “production” and “town” within it, and its intensity directly characterizes the level and activity of the integration of production and town.

#### **4.3.2. Core Explanatory Variable: Level of Digitization (de)**

This study selected the Peking University County Digital Rural Index as a substitute indicator for digitalization levels. The index comprehensively evaluates the digitalization of rural areas in China from eight aspects: digital production, digital supply chains, digital marketing, digital finance, digital governance, digital consumption, digital culture, education, and healthcare, and digital living. It has strong authority and scientific validity (Zhao et al., 2022) and is therefore suitable for the empirical analysis in this study.

#### **4.3.3. Control Variables**

Based on existing research, this study selected the following control variables: 1) Population density (pd): the ratio of the total registered population of a region to its administrative planning area; 2) Agricultural foundation (agr): per capita grain production; 3) Consumption potential (consume): per capita total retail sales of consumer goods; and 4) Resident income (income): per capita disposable income of urban residents.

#### **4.3.4. Descriptive Statistics**

The descriptive statistics of the main variables are shown in **Table 1**. As can be seen from the results in the table, the average value of the level of industry-town integration is 6.688, with a standard deviation of 8.184, indicating that there are significant differences in the level of industry-town integration across different regions. The average value of the digitalization level is 55.340, the median is 55.340, the minimum value is 17.310, and the maximum value is 87.260, indicating that there is a certain degree of polarization in the digitalization levels across

different regions.

**Table 1.** Descriptive statistics of variables.

	Variable	Obs	Mean	SD	Min	Max
explained variable	cp	1508	6.688	8.184	0.014	59.066
explanatory variable	de	1508	55.340	10.142	17.310	87.260
control variables	pd	1508	3.926	3.124	0.002	31.879
	agrf	1508	8.352	0.710	4.969	10.749
	consume	1508	9.290	0.673	6.623	11.870
	income	1508	10.330	0.194	9.003	11.067

## 5. Results and Analysis

### 5.1. Direct Effects

**Table 2** reports the regression results of digital technology on the level of industry-town integration. Column (1) shows the univariate regression based on controlling for county fixed effects and year fixed effects. The regression results indicate that the regression coefficient of the digital technology treatment variable is significantly positive at the 1% level, preliminarily indicating that digital technology empowerment has a significant positive impact on the level of industry-town integration in the region. Considering that characteristics such as population density, agricultural foundation level, consumption potential level, and residents'

**Table 2.** Benchmark regression results.

Variable	(1)	(2)
	cp	cp
de	0.023***	0.022***
	(3.79)	(3.65)
pd		0.365
		(0.74)
agrf		0.693
		(1.15)
consume		0.100
		(0.88)
income		1.787
		(1.03)
Year fixed effect	Yes	Yes
County fixed effects	Yes	Yes
N	1419	1419
Adjusted R <sup>2</sup>	0.986	0.986

Note: \*\*\*, \*\* and \* indicate significance levels of 1%, 5%, and 10%, respectively. The values in parentheses are t-values after controlling for robustness.

income level may influence the industrial-urban integration level of a region, this study further controlled for these variables based on the aforementioned univariate regression. After incorporating these control variables, according to the regression results in Column (2) of **Table 2**, it can be observed that, holding other conditions constant, a 1 percentage point increase in digitalization levels can raise the industrial-urban integration level of the corresponding region by 2.2%. This indicates that the application of digital technology can significantly promote the improvement of industrial-urban integration levels in the corresponding regions, thereby supporting the validity of Hypothesis H1.

## **5.2. Robustness Check**

### **5.2.1. Eliminate the Impact of Outliers**

Considering that outliers in the regression sample may lead to biased estimation results, this study performed tail trimming at the 1% and 99% quantiles for all continuous variables in the benchmark regression, replacing values above the highest quantile and below the lowest quantile, and then re-conducted the regression analysis. The specific regression results are detailed in Column (1) of **Table 3**. It can be observed that the conclusions of this study remain unchanged after removing the outliers.

### **5.2.2. Changing the Dimension of the Cluster-Robust Standard Error**

Considering the robustness of the identification strategy, this study changed the dimension of the cluster-robust standard error and performed cluster analysis at the city level. The regression results are listed in column (2) of **Table 3**. The regression results show that the coefficient of the digitalization level is still significantly positive, and the research conclusion remains valid.

### **5.2.3. Exclude Samples from Special Counties and Cities**

Given the heterogeneity among different county-level administrative regions in various aspects, this study excluded county-level city samples and re-ran the regression analysis. The specific regression results are shown in Column (3) of **Table 3**. The regression results indicate that the level of digitization remains significantly positive at the 1% level, confirming the robustness of the conclusions drawn in the preceding discussion.

### **5.2.4. Controlling for Provincial and City-Level Fixed Effects**

Considering that the core explanatory variables may vary at the provincial or city level, this study controlled for provincial fixed effects and city fixed effects in addition to controlling for year and county fixed effects to avoid endogeneity issues caused by omitted variables. The regression results are shown in **Table 3**, column (4). The coefficient of digitalization level on town-industry integration is still significantly positive at the 1% level.

### **5.2.5. Dual Machine Learning Causal Testing**

After undergoing the aforementioned robustness tests, this study may still be sub-

ject to selection bias, which could potentially impact the robustness of the regression results. Compared to traditional causal inference methods, dual machine learning offers significant advantages in terms of variable selection and model specification. Based on this, this study employs a dual machine learning approach to re-examine the causal relationship between digital technology and urban-rural integration. In this paper, the sample splitting ratio for the dual machine learning method is set to 1:5. Under the control of county and year fixed effects, the quadratic terms of the control variable set are included, and the random forest algorithm is used to predict and solve the main regression and auxiliary regression. According to the results in column (5) of **Table 3**, the regression coefficient for digitalization remains significantly positive at the 1% level. This indicates that after mitigating potential endogeneity issues using the dual machine learning method, the conclusions of this study remain robust.

**Table 3.** Robustness test.

Variable	(1)	(2)	(3)	(4)	(5)
de	0.022*** (3.57)	0.022*** (2.77)	0.043*** (5.87)	0.022*** (3.50)	0.084*** (5.29)
control variables	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
County fixed effects	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	No	No	No	Yes	No
city fixed effects	No	No	No	Yes	No
N	1419	1419	1147	1419	1508
Adjusted R <sup>2</sup>	0.985	0.986	0.984	0.984	

Note: \*\*\*, \*\* and \* indicate significance levels of 1%, 5%, and 10%, respectively. The values in parentheses are t-values after controlling for robustness.

### 5.3. Mechanism of Action Testing

Based on the analysis and arguments presented earlier, we can conclude that digital technology enables the symbiotic integration of industry and towns under the backdrop of common prosperity. This conclusion remains robust after undergoing a series of robustness tests. This section will further examine the mechanisms through which digital technology facilitates the symbiotic integration of industry and towns. Theoretical analysis suggests that digital technology can influence this integration through three channels: residents' wealth accumulation, labor force return, and external demand stimulation. To this end, this paper measures residents' wealth by constructing residents' income levels at the county level, measures labor force return rates using the proportion of rural residents' permanent population in the total regional population, and measures external demand stimulation rates using county export volumes. By examining whether digital technology can

influence residents' wealth accumulation, labor force return, and external demand stimulation, we aim to validate the reliability of the theoretical mechanisms outlined above.

### 5.3.1. Residents' Wealth Accumulation Effect

Digital technology has significantly improved residents' wealth levels by optimizing resource allocation, thereby promoting the integration and symbiosis of industry and towns (Zheng & Liu, 2025). This study uses residents' income levels across counties to represent their wealth levels. According to the regression results in Column (1) of **Table 4**, the regression coefficient for digital technology on residents' wealth levels is 0.00764 ( $p < 0.01$ ,  $t = 2.97$ ), indicating that a 1-unit increase in digital technology leads to a 0.76% increase in residents' wealth levels. This result indicates that artificial intelligence and digital technology can significantly enhance regional wealth accumulation efficiency by reducing transaction costs and optimizing factor allocation. Specifically, digital technology expands agricultural product sales channels through e-commerce platforms and improves capital turnover efficiency through digital payments, directly promoting farmers' income growth and wealth accumulation, thereby strengthening the economic foundation of industrial-urban integration. Assuming H2 is verified.

### 5.3.2. Labor Return Effect

The positive impact of digital technology on labor return rates validates its role in promoting the integration of industry and towns. At the macro level, the stability or increase in the proportion of permanent rural residents in a region usually indicates an enhanced attraction to labor or a slowdown in outflow trends. The creation of job opportunities through the development of local industries driven by digital technology, which attracts out-migrants back to their hometowns, is one of the important factors leading to this increase. Although the increase may also be due to a decrease in the outflow of local labor rather than an increase in active return migration, it still reflects the retention effect of local economic vitality and increased job opportunities on labor, which is consistent with the goal logic of digital technology empowering local industries and promoting the integration of industry and town. Therefore, this paper uses the proportion of permanent rural residents in the total population of the region as an indicator to measure labor return migration. This paper uses the proportion of rural residents' permanent population in the total regional population as an indicator of labor return. Column (2) of **Table 4** shows that the regression coefficient of digital technology on the labor return rate is 0.00246 ( $p < 0.001$ ,  $t = 5.16$ ), indicating that a 1-unit increase in digital technology leads to a 0.25% increase in the labor return rate. Specifically, digital technology has significantly increased migrant workers' willingness to return to their hometowns for employment and entrepreneurship through information dissemination and skill training. Short video platforms (such as Douyin and Kuaishou) provide remote employment information matching services for rural labor, while blockchain technology reduces labor mobility barriers

through the digitization of academic credentials and skill certificates. This “digital talent attraction” effect manifests as a gradual return of labor from cities to specialty industrial towns in the context of industry-town integration. Assuming H3 is verified.

### 5.3.3. External Demand Stimulus Effect

The significant positive impact of digital technology on external export demand highlights its crucial role in expanding international markets. By optimizing production processes and enhancing supply chain responsiveness, digital technology significantly boosts a company’s international competitiveness. In this paper, we use county-level export volumes to represent external export demand. To ensure consistent measurement units, we apply logarithmic transformation to the export volumes of each county. As shown in Column (3) of **Table 4**, the regression coefficient of digital technology on external export demand is 0.00221 ( $p < 0.01$ ,  $t = 3.78$ ), indicating that for every 1-unit increase in digital technology, the contribution rate of external demand to industrial-urban integration increases by 0.2%, thereby validating the leverage effect of digital technology in driving external demand. Assuming H4 is verified.

**Table 4.** Verification of the mechanism of action.

	(1) level of wealth among residents	(2) labor return	(3) Driven by external demand
de	0.00764** (2.97)	0.00246*** (5.16)	0.00221*** (3.78)
control variables	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
County fixed effects	Yes	Yes	Yes
Obs	1419	1419	1419
$R^2$	0.9966	0.9460	0.9868

Note: \*\*\*, \*\* and \* indicate significance levels of 1%, 5%, and 10%, respectively. The values in parentheses are t-values after controlling for robustness.

## 5.4. Heterogeneity Analysis

### 5.4.1. Differentiated Effects between Key and Non-Key Poverty-Stricken Areas

Digital technology can break through the path dependence of traditional industrial development in impoverished areas by optimizing resource allocation and reducing information asymmetry, thereby creating a “digital catch-up” effect. The promotional role of digital technology in the integration of industry and townships exhibits significant differentiation between impoverished and non-impoverished areas. This paper collects the list of 832 national-level impoverished counties nationwide, takes the median value, and classifies regions with fewer impov-

erished counties than the median as non-priority impoverished regions, while regions with more impoverished counties than the median are classified as priority impoverished regions. According to the regression results in columns (1) and (2) of **Table 5**, the digital technology coefficient for key poverty-stricken areas is 0.0594 ( $t = 4.66^{***}$ ,  $p < 0.001$ ), while that for non-key poverty-stricken areas is only 0.00343 ( $t = 0.31$ ,  $p > 0.1$ ). This indicates that the enabling effect of digital technology on the integration of industry and township development is more significant in key poverty-stricken areas than in non-key poverty-stricken areas.

#### 5.4.2. The Gradient Effect of Residents' Income Levels

Digital technology lowers barriers to entry through inclusive access, thereby reinforcing the comparative advantages of low-income regions. Based on this, this paper categorizes regions into those with lower and higher resident income levels based on the median resident income level at the end of the year. As shown in columns (3) and (4) of **Table 5**, the digital technology coefficient for regions with lower resident income is 0.0515 ( $t = 3.98^{***}$ ,  $p < 0.001$ ), while the coefficient for high-income regions is only 0.0104 ( $t = 1.00$ ,  $p > 0.1$ ). This gradient difference confirms the pattern that digital technology is more likely to benefit low-income groups, and the impact of digital technology on town-village integration exhibits a significant “pro-poor” characteristic.

**Table 5.** Heterogeneity test.

	(1) non-priority poverty-stricken areas	(2) key poverty-stricken areas	(3) Areas with relatively low income levels among residents	(4) Areas with relatively high income levels among residents
de	0.00343 (0.31)	0.0594 <sup>***</sup> (4.66)	0.0515 <sup>***</sup> (3.98)	0.0104 (1.00)
control variables	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
County fixed effects	Yes	Yes	Yes	Yes
Obs	373	532	647	627
$R^2$	0.9931	0.9958	0.9849	0.9940

Note: <sup>\*\*\*</sup>, <sup>\*\*</sup> and <sup>\*</sup> indicate significance levels of 1%, 5%, and 10%, respectively. The values in parentheses are t-values after controlling for robustness.

## 6. Conclusions and Recommendations

### 6.1. Research Conclusions

This chapter conducts theoretical analysis and proposes research hypotheses, then uses panel data at the county level in China from 2018 to 2020 to empirically test the enabling effects of digital technology on the integration of industry and towns.

A series of robustness analyses are conducted to validate the empirical results of this chapter. The research findings indicate: First, digital technology can effectively enable the integrated development of industry and towns, and this result remains reliable after a series of robustness analyses. Second, digital technology can promote the symbiotic development of industry-town integration through the wealth accumulation effect of residents, the labor return effect, and the external demand stimulation effect. Third, heterogeneity analysis indicates that the inclusiveness of digital technology makes its enabling effect on the symbiotic development of industry-town integration in key poverty-stricken areas and regions with lower resident income levels more significant. The impact of digital technology on the symbiotic development of industry-town integration exhibits a pronounced “pro-poor” characteristic.

The “pro-poor” characteristics presented in the heterogeneity analysis of this study merit further exploration into the underlying mechanisms. This paper suggests that this “pro-poor” effect may stem from the combined effects of the following two aspects:

1) The “catch-up” potential created by the relatively low baseline level of digitalization and industrial integration development. Key poverty-stricken counties and low-income areas often face development bottlenecks such as weak infrastructure, a single industrial base, a shortage of talent, and limited market access. Their initial levels of digitalization and the degree of integration between industry and town are generally low. A lower starting point means there is greater room for marginal improvement. When digital technology intervenes as a powerful exogenous driving force, the effects it brings, such as relative efficiency improvement, market connection expansion, and accelerated factor flow, are more likely to produce significant “marginal incremental” effects in these regions with lower starting points. This high marginal return brought by a low starting point is a direct manifestation of the “catch-up” potential and an important source of “pro-poor” characteristics.

2) Digital technology possesses unique advantages in overcoming specific obstacles in low-income areas. The inherent characteristics of digital technology enable it to effectively break through many structural obstacles faced in the traditional development path of impoverished areas. Crossing geographical isolation, the Internet and mobile communication technology have broken the constraints of physical space on information acquisition and market participation in remote areas, enabling impoverished areas to directly access national and even global markets. By reducing transaction costs, digital platforms eliminate intermediary links, thereby reducing transaction costs, search costs, and trust costs for producers in impoverished areas, enhancing their market bargaining power and earnings. Addressing shortcomings in human capital, digital inclusive finance, online education, and remote services can alleviate the shortage of professional talents and high-quality services in impoverished areas to a certain extent, empowering local residents and operators. Stimulating endogenous innovation, low-cost digital

tools provide residents in impoverished areas with low-threshold channels to showcase local resources and engage in innovation and entrepreneurship, helping to activate endogenous dynamics.

Therefore, digital technology does not merely “appear” effective because of the low starting point in poor areas. As a general-purpose technology, it possesses breakthrough capabilities in overcoming spatial barriers, lowering the threshold for market participation, providing inclusive services, and empowering small and micro entities. This makes it uniquely and effectively adaptable in addressing core issues that plague low-income areas, such as market failures, information asymmetry, and resource scarcity. The high alignment between this technological characteristic and the key bottlenecks in low-income areas is the underlying reason driving the “pro-poor” effect.

## 6.2. Policy Recommendations

To address the structural contradiction of “having towns without industries” and “having industries without towns”, and to fully leverage the pro-poor empowering role of digital technology in the integration of industries and towns, it is urgent to build a precise empowering system centered around digital technology.

1) Targeting the pro-poor approach: Building a precise delivery system for digital infrastructure in impoverished areas

Implement differentiated digital infrastructure layouts targeting the prominent “pro-poor” effects in impoverished counties and low-income areas. Prioritize the enhancement of digital infrastructure and localization services in impoverished areas, and give priority to the construction of agricultural product blockchain traceability centers and smart warehousing nodes in key impoverished counties. By investing preferentially in hardware such as 5G base stations and cold chain logistics data centers, and supporting township-level “digital service stations” to provide skills training, we aim to overcome the dilemma of “emphasizing hardware over services” in underdeveloped areas.

2) Breaking through the empowerment loop: activating the chain reaction of the three major mechanisms

Deeply activate the three mechanisms of residents’ income increase, labor force return, and external demand stimulation. Leverage e-commerce platforms to build regional agricultural product brands to expand the wealth accumulation effect, and integrate scattered farmers by establishing “one town, one product” live streaming bases, transforming the income increase effect of e-commerce into investment in industries such as cold chain logistics. At the same time, set up digital skill subsidies for returning home employment and training centers in industrial parks, utilizing the “digital translation” function of labor force return to optimize human capital allocation; and implement a “digital apprenticeship system” in areas with weak labor force return, where returning entrepreneurs will train apprentices and provide employment promotion subsidies. For export-oriented short-board counties, deepen the digital upgrade of their export-oriented industries, en-

hance export response efficiency by building cross-border digital supply chain platforms and blockchain traceability systems, provide low-interest digital transformation loans for county export enterprises, strengthen the supporting role of blockchain traceability technology for export premiums, and amplify the driving effect of external demand markets on the integration of production and towns.

3) Innovative institutional supply: Developing reform tools tailored to address structural contradictions

In response to the significant empowering advantages of digital technology in low-income areas, it is necessary to break through traditional institutional bottlenecks. A hierarchical fiscal incentive system should be established, implementing a central and local funding matching mechanism for digital infrastructure in impoverished counties. This requires local investment to be no less than central funding, and strictly restricts the use of matching funds for digital service operations, preventing a disconnect between hardware investment and talent cultivation. We should deepen inclusive financial reforms, allowing farmers to replace traditional collateral with new credit assets such as e-commerce business data and digital skill certifications. Special low-interest loan products should be developed to effectively alleviate financing constraints for small and micro business entities. Innovative land element allocation should be implemented, prioritizing the allocation of land for digital industries in county development zones. Land price discounts should be offered for the construction of data centers, cloud factories, and other facilities using existing land, promoting the agglomeration of digital elements and the restructuring of industrial space.

## 7. Research Limitations and Future Prospects

Although this study strives for rigor, there are still some limitations that need to be overcome in future research:

1) Due to the limitations of data time series, the panel data used in this study has a relatively short time span. Although this helps to capture the immediate effects of the early stages of the digital rural strategy, it is difficult to fully evaluate the long-term dynamic impact of digital technology empowering the integration of industry and town. For example, the maturity of technological applications, deep adjustments in industrial structure, adaptive changes in resident behavior, and cumulative effects of policies often require longer time windows to fully manifest. Short time series may also limit the ability to capture the potential impact of external shocks such as economic cycle fluctuations on research conclusions. If future research can obtain longer-term data, it will be able to more comprehensively and robustly reveal the long-term mechanisms of digital empowerment.

2) The limitations of the matching between the analysis hierarchy and the research object, this study conducts empirical analysis based on county-level data, while the core object of theoretical exploration is the process of “industry town integration” at the township level. Although counties are the direct superior administrative units and important resource coordination platforms of towns, their

data can to some extent reflect the development trends of subordinate towns, and county data has advantages in availability and continuity, there is often significant heterogeneity in the development between towns within counties. Using county-level averages or total indicators for analysis may mask micro level differences at the town level. Future research should actively explore the construction or acquisition of finer grained digital and industry town integration data.

In response to the above limitations, future research can be expanded in the following directions: firstly, continuously tracking the process of digital rural construction, collecting longer-term panel data, and deepening the understanding of the long-term effects of digital empowerment; Secondly, efforts should be made to build a town level database with wider coverage and more comprehensive indicators, in order to achieve a more accurate characterization of the micro mechanism of industry town integration; The third is to combine in-depth case studies and field investigations to verify and enrich statistical findings at the county level, and explore the specific pathways and situational dependencies of digital empowerment in different types of townships.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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