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Industrial Intelligent Infrastructure, Labor Inflow and Integration of the Two Industries—Based on the Empirical Analysis of Guangdong

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Abstract: *Using the panel data of prefecture-level cities in Guangdong Province from 2011 to 2021, this paper investigates the impact of new digital infrastructure on the integration of two industries and its possible spatial spillover effect, and further examines the heterogeneity of different regions and different ways of industrial integration. The results show that: (1) the new digital infrastructure has an obvious promoting effect on the integration of the two industries, and promotes the integration of the two industries by attracting the inflow of labor force. (2) The integration effect of the new digital infrastructure has the heterogeneity of the integration mode. Compared with the coupling degree of the two industries, the new digital infrastructure has a greater impact on the coordination degree of the two industries. (3) The new digital infrastructure has a spatial spillover effect on the development of the integration of the two industries, and the direct regional effect is larger than the spatial spillover effect. This study is helpful to clarify the relationship between the new digital infrastructure and the integration of the two industries, and provide corresponding policy suggestions for promoting the balanced development of the integration of the two industries in Guangdong Province.*

Keywords: *Industrial intelligent infrastructure; Advanced manufacturing industry; Modern service industry; Industrial integration*

1. Introduction

The integration of advanced manufacturing industry and modern service industry (the integration of the two industries) is an important way to enhance the core competitiveness of manufacturing industry and achieve high-quality industrial upgrading. The report to the 20th National Congress of the Communist Party of China clearly pointed out that to build a modern industrial system, we need to promote the deep integration of modern service industries with advanced manufacturing and modern agriculture. Manufacturing is the industrial foundation of Guangdong. With advanced manufacturing industry as the carrier, the traditional manufacturing industry is enabled through modern service industries, such as information technology service industry, scientific research and technical service industry, etc., so as to promote the transformation and upgrading of the manufacturing industry, and form the superposition effect of "manufacturing + service", which is conducive to reshaping the competitive advantage of the manufacturing industry in Guangdong. Industrial intelligent infrastructure represented by industrial robots, cloud computing, and data centers can break the limitations of time and space, promote the formation of a common technical basis for different industries, and make the technological boundaries between industries tend to be blurred to achieve industrial integration. In the classical model of new economic geography, labor migration is the internal factor affecting the spatial aggregation of industries. So, what is the impact of industrial intelligent infrastructure on the spatial allocation of labor, staying or moving elsewhere? Under artificial intelligence technology, what is the impact of labor mobility on industrial integration, and what is the spatial effect? Studying the above issues is conducive to promoting the coordinated upgrading of Guangdong's manufacturing and service industries and shaping a new development pattern.

2. Theoretical mechanism and research hypothesis

Industrial intelligent infrastructure is a kind of public goods with externality and non-competitive characteristics. Its construction and development are conducive to reducing the operating cost of

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enterprises and improving the technical level of enterprises. It can provide a technical standard, improve the production efficiency of enterprises, open up the interconnection of various industries, and improve the production efficiency and transaction efficiency of enterprises.

On the one hand, industrial intelligent infrastructure can optimize the factor allocation of enterprises, and its digital characteristics can alleviate problems such as market segmentation, monopoly and market information asymmetry. Specifically, first, industrial intelligent infrastructure can reduce the cost of enterprise factor search. The development of intelligent technology makes factor communication more concrete and dynamic, improves the knowledge sharing effect of labor force [1], breaks through the time-space limitation of labor force information acquisition, reduces the cost of enterprise factor search, and is conducive to breaking the segmentation of labor factor market [2]. Second, artificial intelligence technology is essentially a change in technical elements. The traditional Cobb-Douglas production model divides production factors into labor, capital and total factor productivity. With the emergence of intelligent technology, digital factors have also become a kind of factors [3]. According to Metcalfe's theorem, the increase of network nodes means that the value increases exponentially. The more data, the greater the value, and the stronger the sharing effect. Data factors can also have an adjustment effect on capital and labor factors. For example, industrial intelligent equipment requires more capital investment in technical assets, such as industrial robots and big data [4]. The labor force also needs to have the technical quality of industrial intelligence to achieve the adjustment and optimization of elements. Third, the efficiency of factor allocation has been improved. The construction and development of information infrastructure promote industrial intelligence [5], and its information is more targeted and personalized. Big data supports the strategic adjustment of enterprises and the improvement of resource utilization efficiency, reduces the transaction costs of enterprises' factors, and strengthens the technical quality of products and services [6].

On the other hand, the improvement of industrial intelligent infrastructure can improve the efficiency of enterprise participation in the division of labor and reduce enterprise costs. Specifically, first, industrial intelligent infrastructure can reduce the production cost of enterprises. The wide application of intelligent technology promotes the digitalization of enterprise production, operation and management, realizes the flexibility of production process and the personalization of product, strengthens product performance management, improves enterprise labor productivity and reduces waste in production process [7]. Second, industrial intelligent infrastructure reduces the cost of coordination for enterprises. Industrial intelligent infrastructure with intelligent technology features provides enterprises with common Internet communication protocols and network ports, improves the speed of network interconnection, and effectively breaks the market segmentation and market entry barriers caused by information asymmetry [8]. Through the common intelligent technical facilities, not only can realize the internal communication and integration of the industry, but also improve the interaction between industries, based on the efficient digital management system, improve the efficiency of external communication of enterprises, and reduce the search cost of industrial interoperability. Based on this, this paper proposes the following hypothesis:

Hypothesis 1: Industrial intelligent infrastructure can promote the deep integration of advanced manufacturing and modern services.

Hypothesis 2: Industrial intelligent infrastructure and labor force factors have a good interaction effect, attracting labor force inflow through production effect, and providing labor force factor basis for the integration of the two industries.

Hypothesis 3: Industrial intelligent infrastructure has a spatial spillover effect on the integration of the two industries, that is, the development of local industrial intelligent infrastructure can improve the integration of the two industries in the surrounding area.

3. Industrial intelligent infrastructure and the characteristic facts of two industries integration

3.1 Industrial intelligence infrastructure

At present, there is no intuitive data of industrial intelligent infrastructure, which is usually measured by building a comprehensive evaluation index system. The new digital infrastructure is different from the traditional Internet infrastructure and digital infrastructure, which not only covers artificial intelligence, cloud computing, big data centers, but also includes the technical application of the Internet of Things and artificial intelligence. Therefore, industrial intelligent infrastructure can not be measured by a single index, and it is necessary to build a comprehensive evaluation index system in order to more comprehensively and objectively reflect the development level of new digital infrastructure. This paper

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constructs a comprehensive evaluation index system of industrial intelligent infrastructure from three dimensions of industrial intelligent basic conditions, investment level and development results, and uses the entropy method to calculate the development degree of industrial intelligent infrastructure in each prefecture level city. See Table 1 below for details.

Table 1: Guangdong Province industrial intelligence index evaluation system

Primary index	Secondary index	Three-level index	Indicator direction	Entropy weight
Industrial intelligent infrastructure development level	Basic condition	Optical cable density	+	0.2394
		The number of Internet users	+	0.0401
		Scale of mobile Internet users	+	0.0363
	Input level	Number of industrial robots imported	+	0.1101
		The proportion of information technology fixed assets in social fixed assets	+	0.0406
		Industrial R&D investment as a share of GDP	+	0.0731
	Development result	Artificial intelligence patent	+	0.3167
		Information transmission computer services and software workers	+	0.0593
		Per capita telecommunications revenue	+	0.0447
		Government work report on the frequency of artificial intelligence keywords	+	0.0398

Figure 1 below is a quad chart of natural disjunction points of the new digital infrastructure of prefecture-level cities in Guangdong Province. It can be seen that Guangzhou and Shenzhen are in the first level, Foshan, Dongguan and Zhuhai are in the second level, Huizhou, Zhongshan, Jiangmen and Zhaoqing are in the third level, and the 12 non-Pearl River Delta cities are in the fourth level, with obvious regional hierarchy.

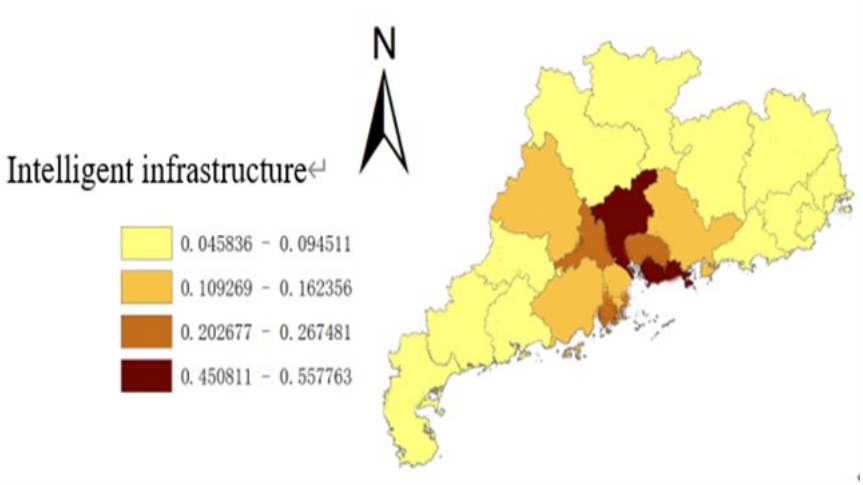

Figure 1: Annual average of Guangdong Industrial intelligent infrastructure Index from 2011 to 2021

Guangdong leads the country in the development of advanced manufacturing industry and modern service industry. From 2011 to 2021, the high-end of manufacturing industry and the modernization of service industry have made remarkable progress. As shown in Table 2 below, the added value of Guangdong's advanced manufacturing industry doubled from 1,032.603 billion yuan to 2,086.93 billion yuan from 2011 to 2021. The development of advanced manufacturing has also led to the leapfrog development of modern service industries, with an increase of more than 3 trillion yuan during the decade. At the same time, it also exposed the structural problems of advanced manufacturing and modern service industries. In 2011, the added value of advanced manufacturing accounted for 47.7% of the added value of industries above designated size, and by 2021, the proportion will be 55.9%, and the development is relatively slow. The proportion of modern service industry in the tertiary industry increased from 55.0% in 2011 to 65.2% in 2021, and the development difference between the "two industries" increased from 8.6% in 2011 to 10.2% in 2021. The development speed of advanced manufacturing industry and modern service industry has mismatched phenomenon, and there is a large space for development of the integration of the two industries.

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Table 2: Development of Guangdong's two Industries from 2011 to 2021

Year	Advanced manufacturing value added(100 million Yuan)	Added value of modern service industry(100 million Yuan)	The degree of coordination between the two industries
2011	10326.03	13392.59	8.55%
2012	10923.69	15036.65	8.87%
2013	12714.98	17173.26	9.94%
2014	13419.81	19438.47	10.81%
2015	14102.48	22338.12	12.55%
2016	15260.88	25568.17	12.99%
2017	17250.14	29709.97	7.56%
2018	18224.53	33198.45	6.53%
2019	17848.93	38127.56	8.89%
2020	18075.60	40492.33	9.15%
2021	20869.30	45443.90	9.82%

4. Model setting and data description

4.1 Model setting

This paper selected 21 prefecture-level cities in Guangdong from 2011 to 2021 to investigate the impact of new digital infrastructure on the integration of the two industries. The explained variable was the degree of integration of the two industries, the core explanatory variable was the comprehensive level of the city's new digital infrastructure, and the intermediary variable was the net inflow of labor force. Considering the impact of other variables on the degree of integration of the two industries, the following regression model was constructed:

$$COV_{it} = \alpha_0 + \alpha_1 INT_{it} + \sum_{k=2}^{6} \alpha_k X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

$$LAR_{it} = \beta_0 + \beta_1 INT_{it} + \sum_{k=2}^{6} \beta_k X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

$$COV_{it} = \gamma_0 + \gamma_1 INT_{it} + \gamma_2 LAR_{it} + \sum_{k=3}^{6} \gamma_k X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (3)$$

Where, COV_{it} is the integration development degree of two industries of city i in period t, INT_{it} is the comprehensive level of new digital infrastructure of city i in period t, LAR_{it} is the net inflow of labor force of city i in period t, and X_{it} is the set of control variables of city i in period t. μ_i and γ_t represent the unobservable region fixed effect and time fixed effect, respectively, and ε_{it} is a random error term.

4.2 Data specification

The explained variable was the degree of integration of the two industries (COV).

The evaluation index system of the integration of the two industries is constructed from three perspectives: scale, potential and structure. See Table 3 below for details.

Table 3: Evaluation index system of the integration of two industries

Dimensionality	Advanced manufacturing industry	Modern service industry
Scale	Value added/billion Yuan	Value added/billion Yuan
Potential	Value added growth rate /%	Value added growth rate /%
Structure	Value added/Industrial value added above designated size	Value added/Service industry value added

After the evaluation index system is determined, the coupling coordination model is used to calculate the integration development degree of the two industries. Firstly, the comprehensive level of advanced manufacturing industry and modern service industry is calculated using the entropy value method, which is expressed by man_{it} and ser_{it}respectively. Based on this, the coupling index of the two industries is calculated:

$$C_{mst} = \frac{\sqrt{man_{it} \times ser_{it}}}{(man_{it} + ser_{it})} \quad (4)$$

Secondly, give equal weight to both, indicating that advanced manufacturing industry and modern service industry are equally important, so as to calculate the development coordination index of the two:

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$$T_{mst} = 0.5 \times man_{it} + 0.5 \times ser_{it} \quad (5)$$

Finally, according to formula (2) and formula (3), the coupling coordination index of advanced manufacturing industry and modern service industry is calculated:

$$COV_{it} = C_{mst} \times T_{mst} \quad (6)$$

The core explanatory variable is industrial intelligence infrastructure (INT), calculated according to the previous feature facts partial method.

The intermediary variable was the net inflow of labor force (LAR), which was calculated by the net inflow of labor force in Guangdong prefecture-level cities in the current year.

Considering the problem of alleviating endogenous problems and mitigating the bias estimation caused by missing variables on regression results, the following control variables are selected: Economic development level ($lnPGDP_{it}$) is represented by the gross domestic product per capita at constant price in 2010 and logarithm; Foreign direct investment (FDI_{it}) is expressed as the proportion of the actual utilization of foreign capital to the gross regional product. The intensity of government support (GOV_{it}) is expressed by the proportion of government general public budget expenditure to the gross regional product. Urbanization level ($URBAN_{it}$) is expressed by the proportion of urban population to permanent resident population at the end of the year. Wage level ($lnWage_{it}$) is represented by the average wage of employees on the job and logarithm.

5. Analysis of empirical regression results

The baseline regression results are shown in Table 4 below. Column (1) of Table 4 shows the regression results without adding control variables, and column (2) shows the regression results with adding control variables. Columns (3) and (4) show the regression results of splitting the integration degree of the two industries into coupling degree and coordination degree. It can be seen from the results that the estimated coefficient of industrial intelligent infrastructure (DIG) is always positive and passes the 1% significance level test with or without the addition of control variables. Every 1 unit increase of the new digital infrastructure can promote the integration of the two industries by 0.3093 units, which verifies the research hypothesis 1. The integration degree of the two industries is divided into coupling degree and coordination degree, and the results show that every 1 unit increase of the new digital infrastructure can promote the coupling development of the two industries by 0.0954 units, and the coordinated development of the two industries by 0.5946 units.

Table 4: The regression result of industrial intelligent infrastructure to the integration of two industries in Guangdong

Explanatory variable	(1)	(2)	(3)	(4)
	Integration	Integration	Coupling	Coordinate
INT	0.3937*** (0.0477)	0.3093*** (0.0548)	0.0954** (0.0381)	0.5946*** (0.0842)
Control variables	No	Yes	Yes	Yes
Constant	0.1620*** (0.0070)	1.1404** (0.5014)	-0.4343 (0.5042)	1.6315** (0.6710)
R2	0.3110	0.3818	0.0346	0.5436
Cities fiexd effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Obs	252	252	252	252

According to the above theoretical analysis, industrial intelligent infrastructure has a production effect, which can promote the agglomeration of different industries, provide new jobs for the labor force, promote the net inflow of labor force, and then provide the labor force foundation for the integration of advanced manufacturing industry and modern service industry. Table 5 below tests the intermediary mechanism of the net inflow of labor from industrial intelligent infrastructure and the integration of the two industries. It can be seen from the results that industrial intelligent infrastructure has a production effect and can attract labor inflows, thus promoting the deep integration of advanced manufacturing and modern service industries. This paper tests research hypothesis 2

With the deep integration of industrial factors in various prefecture-level cities in Guangdong, the economic ties of cities are increasingly enhanced, and the barriers to factor flow are reduced. It is no longer applicable to study the impact of factor endowment on the economy of cities alone. In this regard,

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the spatial correlation between cities should be considered [9][10]. Based on this, the spatial econometric method is used to analyze the spatial overflow mechanism of the new digital infrastructure to the integration of the two industries. In this study, SDM model can better explain the influence mechanism of new digital infrastructure on the integration of "two industries". The direct effect, indirect effect and total effect of the new digital infrastructure on the integration degree of the two industries are all positive, indicating that the new digital infrastructure not only has a significant promotion effect on the development of the two industries in the local area, but also forms a spatial diffusion effect to promote the integration development of the two industries in the surrounding area.

Table 5: The mediation effect test of the net inflow of labor force

Explanatory variable	(1)	(2)
	Labor	Integration
INT	4.7429***	0.2351***
	(0.8652)	(0.0470)
LAR		0.0219***
		(0.0059)
Control variables	Yes	Yes
Cons	-1.2371	0.1994*
	(1.2908)	(0.1012)
R2	0.8694	0.9610
Cities fiexd effect	Yes	Yes
Time fixed effect	Yes	Yes

6. Conclusions and policy recommendations

This paper finds that the new digital infrastructure can significantly improve the development level of the integration of the two industries in the region, and the promotion effect of the integration of the two industries is weak and not significant. In terms of intermediary mechanism, industrial intelligent infrastructure can significantly promote the inflow of labor, and thus promote the deep integration of the two industries. In terms of spatial mechanism, the new digital infrastructure has a spatial spillover effect on the integration of the two industries, and the direct effect is greater than the indirect effect. This conclusion provides an empirical basis for the subsequent research on the internal mechanism of industrial intelligent infrastructure and industrial upgrading.

Based on the above conclusions, this paper puts forward the following policy recommendations. On the one hand, continue to promote and improve the construction of industrial intelligent infrastructure, and increase the development of 5G, data centers, cloud computing and artificial intelligence, improve the attention of local governments to these industrial intelligent infrastructure, and give full play to the promotion effect of new digital infrastructure on the integration of the two industries. Secondly, to promote the balanced development of industrial infrastructure areas, to give technical and financial support to the regions with backward new digital infrastructure, through policies and measures and industrial chain connection to lead to the technological integration of developed areas and backward areas. At the same time, the implementation of reasonable talent introduction policies to promote the balanced allocation of labor factors in Guangdong Province, improve the efficiency of infrastructure construction, and better release the spillover effect of the integration of the two industries of industrial intelligent infrastructure.

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