PIONEER
ACADEMIC PUBLISHING LIMITED

Journal of World Economy
ISSN 2709-3999
www.pioneerpublisher.com/jwe
Volume 3 Number 2 June 2024

# Dynamics of Distribution, Industry Associations and Convergence Analysis in China's Digital Economy Development

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doi:10.56397/JWE.2024.06.10

**Abstract**

This paper measures the scale of digital industrialization and industrial digitalisation in 30 provinces in China from 2002 to 2017 based on the input-output table, and analyses the evolution dynamics, industrial association characteristics and their convergence using Kernel density estimation, Dagum Gini coefficient, and economic convergence model. The results of the study show that there is a regional imbalance in the development of China's digital economy with the coast being lower than the inland; the difference in the distribution of dynamics within the four major economic regions is gradually expanding, with the most obvious in the central and western regions; the characteristics of the digital industrialization correlation show the evolution path of "energy industry → service industry → manufacturing industry → agriculture"; there is a convergence in all aspects of the digital economy in the country, and the economic convergence model is applied to each economic region. There is σ — convergence in all aspects of the digital economy in the country as a whole, and the results of σ — convergence in each economic region are somewhat different; β — absolute convergence exists in the country as a whole and in each economic region, and only the central and northeastern parts of the country have insignificant results in conditional β convergence. The overall rate of convergence is characterized by "East > West > Central > Northeast".

**Keywords:** digital industrialization, industrial digitalisation, inter-industry relationships, convergence

## 1. Introduction

China's digital industrialization and industrial digitalisation have become an important engine driving the development of digital economy. Since China's digital economy sailed into a high-speed development track in 2002, after 11 years, it entered into a mature development stage in 2013 (Ding Y, Zhang H & Tang S., 2021), following the release of the scale of China's digital economy in 2016, which reached 22.6 trillion yuan (Z. Li & Y. Liu, 2021), and the digital economy was written into the Chinese government's work report for the first time in 2017, and the scale of China's digital economy reached 50.2 trillion yuan in 2022, with the proportion of GDP reached 41.5%, the scale of digital industrialization reached 9.2 trillion yuan, and the scale of industrial digitalisation was 41 trillion yuan (Hou M., 2023). In the report of the 20th Party Congress, the Party Central Committee once again stressed the goal of building a digital China, and General Secretary Xi Jinping put forward important instructions such as “the development of the digital economy is of great significance, and it is a strategic choice for grasping the new round of the scientific and technological revolution and the new opportunities of industrial change,” “the digital economy is related to the overall situation of national development,” etc., which guided the development of the digital economy. In 2023, the CPC Central Committee and the State Council issued the “Overall Layout Plan for the Construction of Digital China”, which not only provides top-level design and policy support for the development of digital economy, but also brings more market opportunities and competitive advantages for related enterprises. However, compared with the practice of rapid development of the digital economy, its related theoretical development is relatively lagging behind, especially the accounting method, the academia and the industry have not yet reached a consensus, according to the consistent practice of the academic community, this paper also divides the digital economy into the digital industrialization and industrial digitalisation two dimensions, and bases on these two dimensions to conduct analysis.

The current measurement of the size of the digital economy is more popular in the value-added method (Zhang, T., & Li, N., 2023; Knickrehm M, Berthon B & Daugherty P., 2016), index method (Cen T, Lin S & Wu Q., 2022; Chinoracky, R. & Corejova, T., 2021; Sidorov A & Senchenko P., 2020; Yanting Xu & Tinghui Li, 2022; Barefoot K, Curtis D, Jolliff W, et al., 2018), satellite account method (Midmore P, Munday M & Roberts A., 2006), the three methods have their own advantages and disadvantages. The advantage of the index method is that it can account for the digital economy year by year, and the disadvantage is that the differences in the construction of the index system lead to inconsistent results, in addition, the method will be difficult to obtain data. Although the satellite account method has the advantage of being able to supplement the economic activities not covered by the indicator system, the method is not yet perfect in China’s digital economy accounting, and there is also the problem of difficult data acquisition. The value-added method, on the other hand, makes use of the input-output table, especially for the study of provincial areas, which will be more unified and more applicable to the study of industrial linkages. In view of this, this paper tries to use the value-added method from the input-output table to more objectively and accurately portray the scale of the development of digital industrialization and industrial digitalisation, and tries to measure the scale of digital industrialization by drawing on the method of Cen and Lin to measure the digital economy, and then explores the dynamics of the regional distribution of the two, as well as the characteristics of the digital industry linkage and the convergence of the two (Cen T, Lin S & Wu Q., 2022).

The divergence of digital industry association studies stems from the division between digital industrialization and industrial digitalisation in the input-output table. Some scholars have classified both industrial digitalisation and digital industrialization as sectors in the input-output table (Guo X, Xu D & Zhu K., 2023), although in the study by Zhang & Zhao (2021), the value added of digital industrialization is defined as the digital convergence part of the value added, i.e., the proportion of digital inputs in the inputs of other industry sectors. The digital convergence part of the economy, i.e., the digital part of the industry considered in this paper, was measured using the full consumption coefficient of the input-output table, and the digitalisation of the industry was set up in this way due to the belief that the digitalisation of the industry should be included in the production process of each industry, i.e., the digitalisation of the industry is a part of the value added of the industry. However, in the studies of both measurement methods, scholars have consistent conclusions in terms of the importance of the development of the digital economy to the manufacturing industry (Liu, Yi, Xuan Zhao, & Fanjun Kong, 2023; Wang M, Zhang M, Chen H & Yu D., 2023; Deng, Haiyan, et al., 2022). Although the interpretation of the degree of digital economy industry linkage to the manufacturing industry at the national level has been more comprehensive, there is still room for exploring the research on the heterogeneous characteristics and evolution path of digital economy industry linkage at the provincial level. This paper explores the development paths of digital industrialization in agriculture, energy, manufacturing and services in each province based on the industrial linkage characteristics of the digital economy in each province, improves the shortcomings of the existing literature, and gives the corresponding digital industrialization planning suggestions.

The relevant literature on the regional distribution and convergence state of digital economic development is quite fruitful. The current academic convergence of the digital economy convergence method are convergence and convergence, the conclusion is mostly based on the East - West development differences, and presents a decreasing characteristic from East and West (Yu Z, Liu S, Zhu Z, et al., 2023; Liu L, Gu T & Wang H., 2022; Zeng W, Liu S & Ma L., 2023; Du M, Huang Y, Dong H, et al., 2022), the digital economy on the provincial and regional economy there is a condition of convergence and has a positive role in promoting. In this paper, we will improve the shortcomings of most scholars' analyses on the regional differences of digital economy and the difference between digital industrialization and industrial digitalisation, so as to further develop a more detailed analysis of the two perspectives.

## 2. Digital Economy Scale Measurement and Data Description

### *2.1 Measurement of the Scale of Digital Industrialization*

#### 2.1.1 Accounting Method for the Scale of Digital Industrialization

Drawing on Cen and Lin (2022) measurement methodology, this paper divides the digital industrialization accounting into four components: digital empowerment infrastructure, digital transactions, digital media, and digital economy transaction products. Due to the availability of data, this paper substitutes the adjustment coefficients for the digital media component in each province with national data.

#### 2.1.2 Methodology for Accounting for the Digital Size of the Industry

The digital size of the industry will be measured using the full consumption coefficients of the input-output tables. Due to the differences in the frequency of publication of input-output tables and the number of sectors in the tables in each province since 2002, sector 42 is used uniformly in provincial input-output tables, except for the national input-output table. This part needs to reconstruct the input-output table according to the purpose of the study, and the reconstructed input-output table has two sectors, namely other sectors and digital industrialization sectors. By calculating the full consumption coefficient of this input-output table as an adjustment factor for the calculation of the industrial digitalisation scale, the product of the value added of the other sectors and the full consumption coefficient is used as the digitalisation scale of the industry in the province.

#### 2.1.3 Accounting for the Size of the Digital Economy

This paper adopts the measurement method of the vast majority of scholars, that is, the digital economy is divided into two parts of the digital industrialization of industrial digitalisation. So the scale of the digital economy is the direct sum of the scale of digital industrialization and the scale of industrial digitalisation.

### *2.2 Data Description*

#### 2.2.1 Variable Design

The core variables in this paper include digital industrialization per capita and digitalisation of industry per capita, all of which are price-adjusted with 2002 as the base period. Giving the research of other scholars on influencing factors, variables such as GDP per capita, urban employment and other variables are used as control variables in the analysis of the convergence of China's digital economy. The specific variable descriptions are detailed in Table 1.

**Table 1.** Description of variables

| Variable type | Variable name | Variable description |
|---|---|---|
| per sdi | Scale of digital industrialization per capita | Real value added of digital industrialization divided by population at the end of each year |
| per sid | Scale of industry digitalisation per capita | Digitised real value added by industry divided by population at the end of each year |

| | | |
|---|---|---|
| per gdp | Per capita GDP | Real per capita GDP |
| ue | Number of urban employment | Number of persons employed in urban areas by province |
| stu | Number of students per 10,000 population | Number of university students per 10,000 population in each province |
| rd | R&D expenditure of industrial enterprises above designated size | R&D expenditure ofindustrial enterprises above designated size in each province |
| pl | Number of patents granted | Number of patents granted at the end of each year |
| is | industrial structure | Total output of secondary and tertiary industries as a share of GDP |

2.2.2 Data Sources

The data in this paper come from the national and 30 provincial input-output tables for 2002, 2007, 2012 and 2017 that have been released, as well as the provincial statistical yearbooks for the corresponding years. Since most of the provinces' multi-sectoral input-output tables are missing digital media-related data, the national digital media adjustment coefficients are chosen to measure the digital media scale of each province.

## 3. Dynamic Analysis of the Distribution of China's Digital Economy

*3.1 Reporting of Measurement Results*

From 2002 to 2017, China's per capita digital industrialization scale, industrial digitalisation and digital economy scale all maintained a steady upward trend. Among them, the per capita digital industrialization scale rose from 525 yuan in 2002 to 3,417 yuan in 2017, an increase of more than 5.5 times, with an average annual growth rate of 13.3%; the per capita industrial digitalisation scale also increased from 813 Chinese yuan in 2002 to 4,636 yuan, an increase of about 4.7 times, with an average annual growth rate of 12.3%; and the per capita digital economy scale, as the first two combined, the growth also expanded by a factor of 5, with an average annual growth rate of 12.7 per cent. The rapid growth of the digital industrialization component has been largely driven by the Government's promotion of the digital economy.

*3.2 Visualisation of the Evolution of Regional Distribution*

According to the results of the previous measurements, it can be seen that the pattern of the digital economy and its digital industry and the level of industrial digital development in the country shows a southward shift in the centre of gravity. Digital industrialization, industrial digitalisation and the digital economy have all shown a southward shift of the centre of gravity over the past 15 years, with the northern region gradually slowing down in the development of the digital economy and showing a tendency for the centre of gravity to be gradually replaced by the central region.

The formation of digital economy distribution dynamics is closely linked to the distributional shifts in digital industrialization and industrial digitalisation, again showing a larger per capita scale in the eastern coastal region than in the central and western regions. Specifically, the per capita scale of industrial digitalisation in the central and western regions has been reduced by some provinces in their echelons, such as Hebei, Jiangsu, Zhejiang and other regions, at a relatively slower pace.

*3.3 Characterisation of the Spatio-Temporal Distribution*

3.3.1 Kernel Density Estimation

In order to further characterise the spatio-temporal evolution of China's digital economy and its digital industrialization and industrial digitalisation, this paper adopts the kernel density estimation method for analysis. According to Figure 1, it can be seen that the kernel density distribution curve gradually shifts the main peak to the right from 2002 to 2017, indicating that both digital industrialization and industrial digitalisation in the country show a growing trend. In addition, the height of the main peak gradually declined, and the right trailing tail gradually showed ductility, indicating that the differences between provinces gradually expanded, and regions with high digitalisation levels gradually pulled away from other provinces.

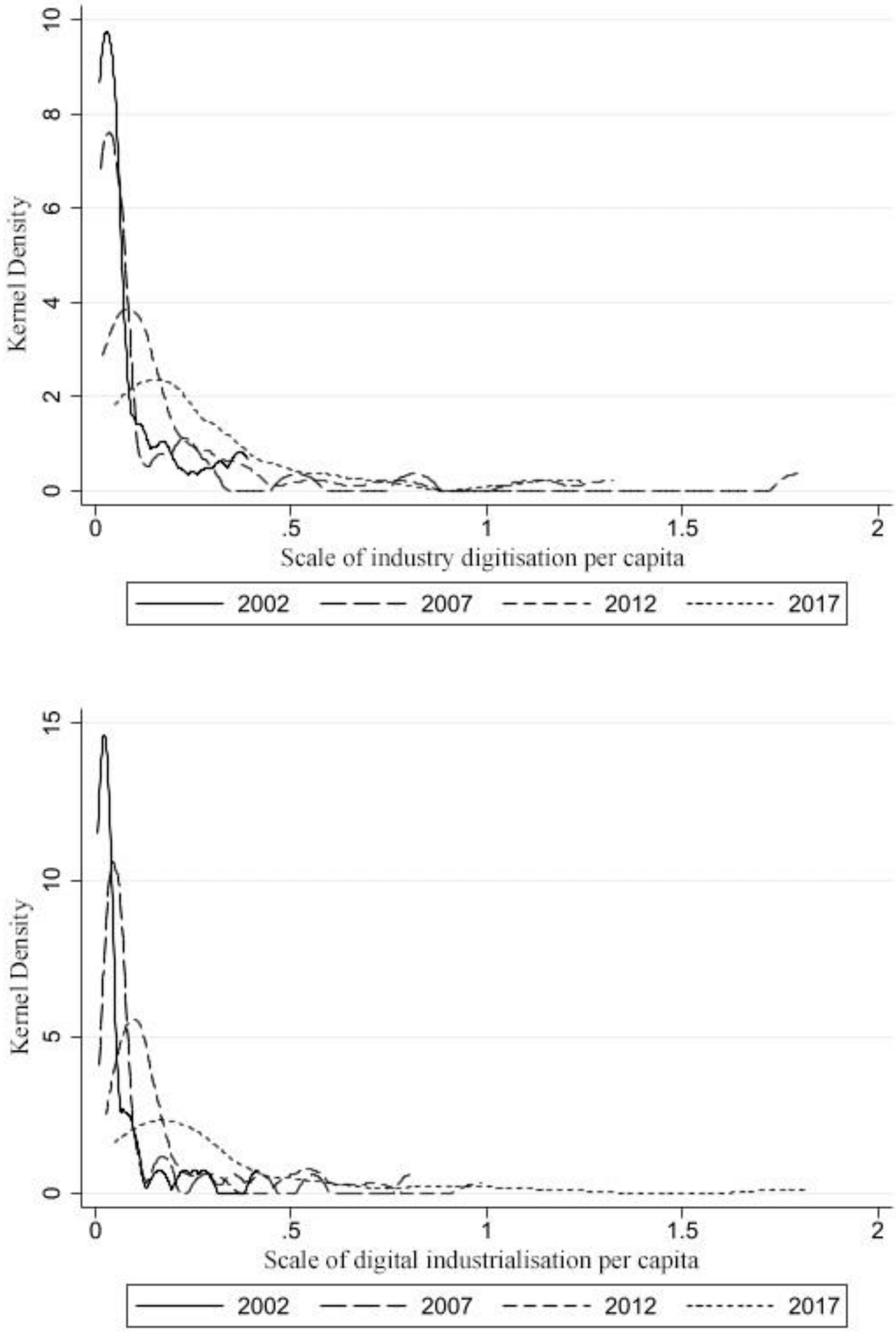



**Figure 1.** Dynamics of distribution of overall digital industrialization and industrial digitalisation in China

As a whole, the four major economic regions of China as a whole roughly show a flattening trend with the main peak height declining and shifting to the right, and the trailing tail gradually becoming longer. Among them, the gap in industrial digitalisation in the northeastern region has gradually widened in recent years; industrial digitalisation in the eastern region has shown signs of a rebound in concentration; and the central region has similar characteristics to the western region, both of which produced a cliff-like decline in distribution concentration in 2012, with the gap between digital industrialization and industrial digitalisation between the provinces gradually increasing.

The differences in the level of digital industrialization in the eastern region were relatively small in 2002, and gradually increased in 2017, but there was no "Matthew effect". There was a certain "Matthew effect" in industrial digitalisation in 2012, with polarisation between high and low levels of industrial digitalisation, which was mitigated in 2017, but gradually concentrated towards low levels. The level of digital industrialization in the central region was more concentrated in 2002, although it gradually became heterogeneous, with the greatest variability between provinces by 2017, which is also related to the different internal conditions of economic development in the central region provinces. The level of industrial digitalisation was similarly characterised by large differences in 2017. The reason why the central region presents such a characteristic is not unrelated to its internal provincial links, and the industrial structure composition of the provinces is an important reason for this phenomenon. Since 2002, digital industrialization and industrial digitalisation in the western region have shown the development of narrow bandwidth to wide bandwidth, such as in Chongqing, Sichuan and Shaanxi, the degree of digitalisation has been developing rapidly since 2002, which is also the reason for the big difference. Similar to the central region, the distribution of concentration in the western region declined precipitously in 2012, gradually forming a distribution situation in which low-sized provinces are concentrated and high-sized provinces are dispersed.

3.3.2 Dagum Gini Coefficient

(1) Intra-regional differences

Intra-regional differences are mainly characterised by the following features: firstly, digital industrialization in the central, eastern and northeastern parts of the country is characterised by decreasing inequality, while the western part of the country is characterised by a tendency of gradually increasing inequality; secondly, the eastern part of the country is characterised by a tendency of gradual convergence in the degree of inequality in the development of industrial digitalisation in the various provinces, even though the degree of inequality in industrial digitalisation is most serious.

Overall, the overall national Gini coefficient of digital industrialization and industrial digitalisation gradually increased from 2002 to 2007, showing a smaller trend, indicating that at the national level, the digital industry has gradually transformed from the pioneering development of certain provinces to the synergistic development of provinces and regions, and the development gap has gradually narrowed.

Specifically, as shown in Figure 2, digital industrialization in addition to the western part of the region presents the characteristics of inequality the rest are all at the beginning of 2007 to 2017 the degree of inequality gradually become smaller, which shows that some provinces in the western region of the level of digital industrialization of the development of the faster speed, such as Chongqing, Sichuan and so on. The level of industrial digitalisation shows the degree of digitalisation of the remaining industries in the region in addition to the digital industry, it can be seen that only the eastern region in the state in 2007 showed a trend of gradually reducing the development gap, while the increase in 2002 to 2007 is considered to be due to the digital industry has just started, and only a few provinces have carried out rapid development, such as Beijing, Guangdong and other provinces. The rest of the regions have seen their internal inequalities deepen despite the small value of the coefficients.

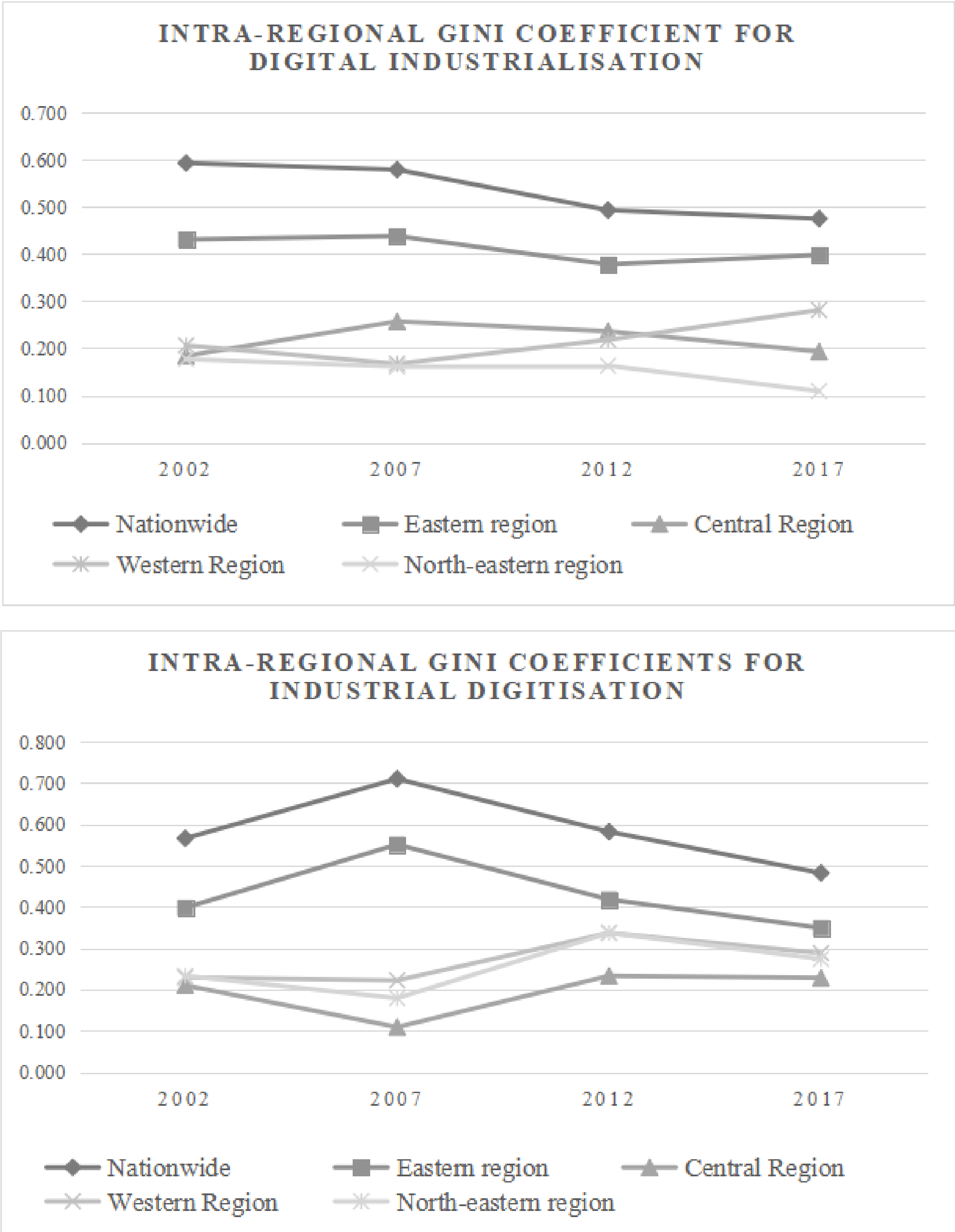
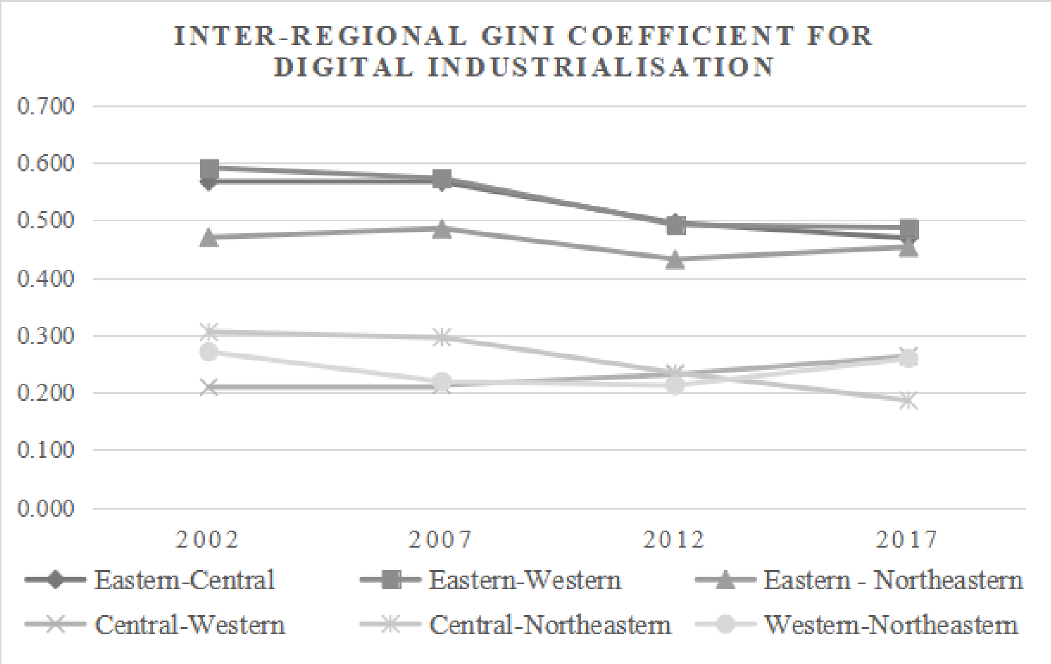



**Figure 2.** National and intra-regional differences in digital industrialization and industrial digitalisation in China

(2) Interregional differences

The regions linked to the eastern region both show a broadly decreasing trend in the degree of intra-regional variation in digital industrialization and industrial digitalisation. The North-East and West regions have relatively low levels of digitalisation development and are more different from the other regions.

According to Figure 3, in terms of digital industrialization, the development gap between the central region and other regions leads to an excessively large Gini coefficient, and the differences between other regions do not change significantly and remain low. As for industrial digitalisation, there is a trend that the Gini coefficient of the region linked to the eastern region increases and then decreases, and the difference between the rest of the regions decreases and then increases, which indicates that the development of industrial digitalisation is extending from the east to the inland region, and the level of industrial digitalisation in the inland region is gradually strengthening, but for the western region and the northeastern region, industrial digitalisation is developing more slowly.



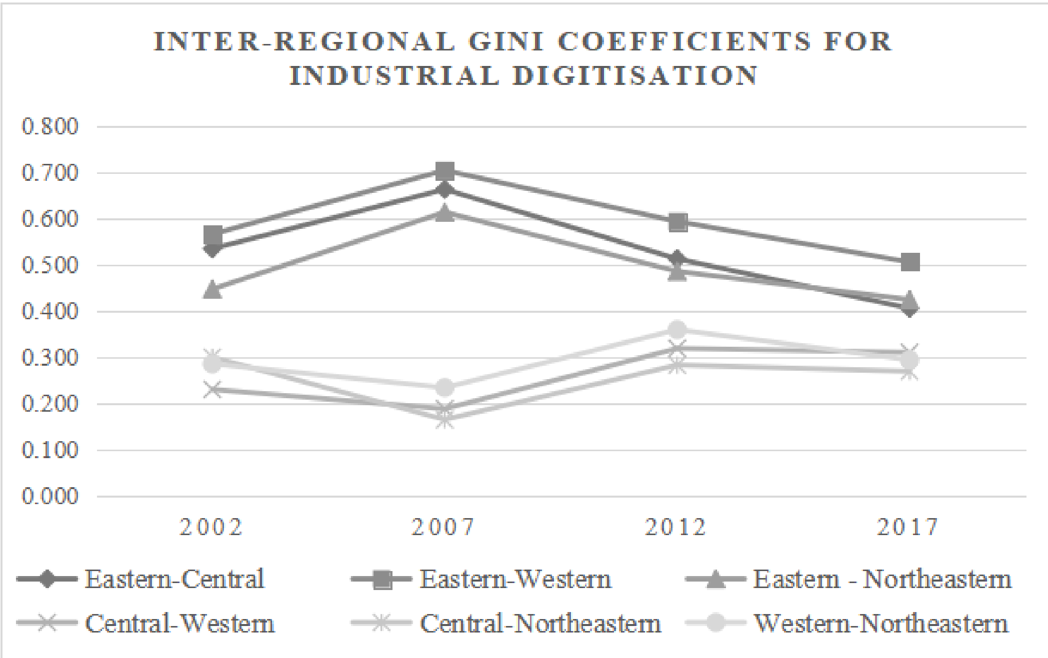




**Figure 3.** Inter-regional differences between digital industrialization and industrial digitalisation in China

(3) Sources and contribution of regional differences

The study found that, as shown in Table 2, the current level of provincial differences between digital industrialization and industrial digitalisation still depends overwhelmingly on the contribution of inter-region, which remains above 60%; the contribution of intra-region and hypervariable density in digital industrialization is gradually increasing, in gradually detaching from the influence of inter-region; and the influence of industrial digitalisation inter-region has also been gradually decreasing, and the influence of hypervariable density has been gradually increasing on it.

Specifically, the intra-regional contribution of digital industrialization has shown an increase. This indicates that many regions have a large gap in the development of digital industrialization within the region, while the gap between the regions as a whole is gradually narrowing, perhaps due to the driving effect mentioned by certain provinces on the region as a whole, such as the pulling effect of Chongqing and Sichuan on the western region. Industry digitalisation shows a first increase and then decrease within the region during the period from 2002 to 2017, while the contribution of the inter-region gradually decreases, but still remains above the 70% level. In conclusion, the Gini coefficient decomposition shows that inter-regional differences are still an important influence on the overall differences, but the problem of intra-regional differences cannot be ignored.

**Table 2.** Dagum Gini coefficient decomposition of digital industrialization and industrial digitalisation in Chinese provinces, 2002-2017

| | Year | Overall | Intra-regional | Contribution(%) | between regions | Contribution(%) | Hypervariable density | Contribution(%) |
|---|---|---|---|---|---|---|---|---|
| digital industrialization | 2002 | 0.593 | 0.122 | 20.601 | 0.461 | 77.800 | 0.009 | 1.599 |
| | 2007 | 0.579 | 0.122 | 21.091 | 0.441 | 76.103 | 0.016 | 2.807 |
| | 2012 | 0.493 | 0.105 | 21.278 | 0.359 | 72.823 | 0.029 | 5.899 |
| | 2017 | 0.475 | 0.111 | 23.314 | 0.317 | 66.696 | 0.047 | 9.989 |
| Industrial digitalisation | 2002 | 0.566 | 0.113 | 20.006 | 0.431 | 76.098 | 0.022 | 3.896 |
| | 2007 | 0.710 | 0.166 | 23.338 | 0.537 | 75.651 | 0.007 | 1.011 |
| | 2012 | 0.582 | 0.124 | 21.302 | 0.433 | 74.393 | 0.025 | 4.306 |
| | 2017 | 0.482 | 0.100 | 20.766 | 0.352 | 71.998 | 0.030 | 6.283 |

## 4. Characteristics of Provincial Digital Economy Industry Association

### *4.1 Analysis of Full Consumption Coefficient*

The degree of digitalisation of each industry in China from 2002 to 2017 presented in Table 3 is a ranking based on the size of the coefficient of full consumption of digital industrialization in each industry in the four years of the country. The table shows that digital industrialization is always in the leading position of digitalisation, the digitalisation degree of manufacturing and service industries gradually increases, the digitalisation degree of energy industry goes down, and the digitalisation degree of agriculture is always in a lower position.

According to the evolution of the degree of digitalisation of various industries in China, a general development path can be obtained, i.e., firstly, the digital upgrading of industries should be carried out in accordance with the path of "energy industry→service industry→manufacturing industry→agriculture", but the development path may be adjusted moderately in accordance with the characteristics of the provinces' territories and resources.

As shown in Figure 4, the vertical axis indicates the degree of digital industrialization (digital industrialization scale per capita) and the horizontal axis indicates the degree of digitalisation of each industry (full consumption factor). The specific digitalisation path of each province is obtained through the phase diagram of the degree of digitalisation in 2017. In general, the provinces above the horizontal axis are mostly in the eastern coastal regions, indicating that the development of digital industrialization in these regions lies above the average level; the provinces located in the third quadrant of the graph are the most numerous and are dominated by the central, western and northeastern regions, indicating that the digitalisation of industries and the degree of industrial digitalisation in these regions are both relatively weak.

Specifically, the degree of agricultural digitalisation in the provinces below the average level accounted for the vast majority, but for agriculture should not be all provinces of agricultural digitalisation should be higher, for several of China's agricultural provinces, such as Heilongjiang, Henan, Shandong, Anhui, Jilin and other places. Henan is just at the average level position, and Heilongjiang, Jilin and other places in the degree of agricultural digitalisation is not high, combined with the degree of digitalisation of other industries, only the degree of digitalisation of the rest of the industry in Heilongjiang and Jilin is also low, so it should be based on the "service industry → manufacturing industry → agriculture" path to digital transformation, due to the energy industry is not its pillar industry, so the energy industry is not the mainstay of the industry, so it is not the mainstay of the industry. Since the energy industry is not its pillar industry, it can start with the service industry in the digitalisation path.

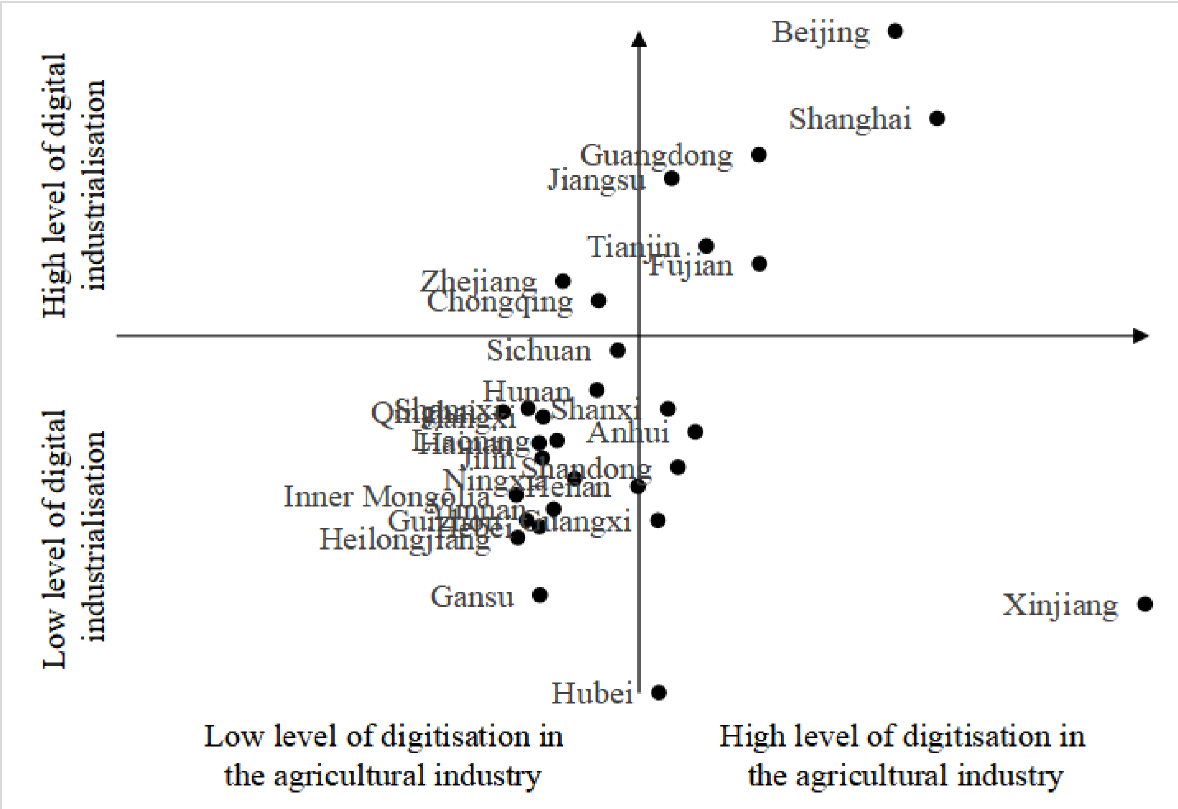
In the digitalisation of the energy industry, China's energy industry is an important industry in the provinces of Shanxi, Chongqing, Liaoning, Xinjiang and other places, it can be seen that Shanxi, in addition to the low degree of digitalisation of the manufacturing industry, the rest of the industry is at the average or above, so that it should be taken to strengthen the development of the path of "manufacturing → agriculture". Chongqing is mainly a mountainous region, its manufacturing and service industries are at the average level, while the energy industry has a higher degree of digitalisation, so it should adopt the path of "service industry → manufacturing industry → agriculture" for digital development. Liaoning, as a province in the third quadrant, has a low level of digitalisation in almost all industries, so it should follow the overall development path of "energy industry → service industry → manufacturing industry → agriculture". Xinjiang, as a result of its late development, has faster industrial transformation and higher digitalisation, but its digital industrialization is not high, so it can accelerate the development of its digital industry itself.

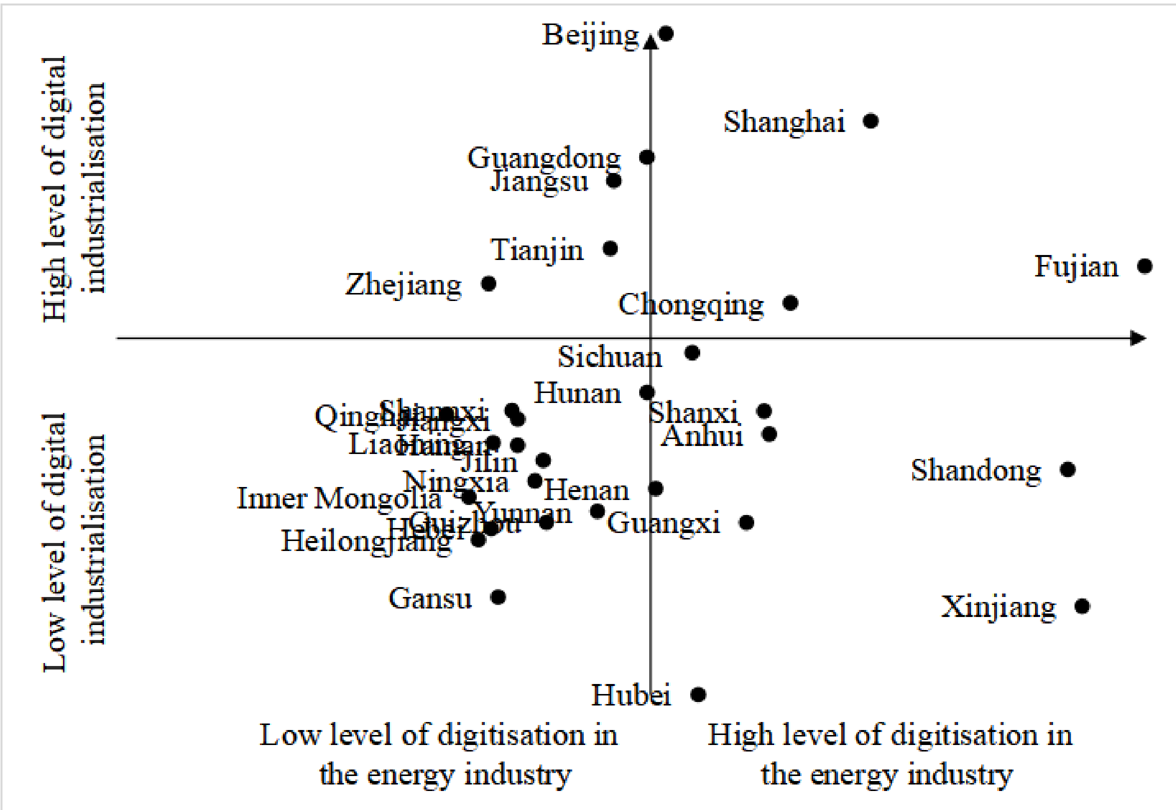
In the manufacturing and service industries, as can be seen from the figure, the provinces in the third quadrant are mostly concentrated in the central and western regions. Combined with the phase diagram of the digitalisation level of the service industry, the rest of the provinces except Hubei and Shanxi not only have a low digitalisation level of the service industry, but also a low digitalisation level of the manufacturing industry. In addition, Sichuan, as a manufacturing-oriented province, the digitalisation level of its manufacturing industry has just reached the average level, so it is still necessary to pay attention to the digitalisation of the manufacturing industry, and these provinces should carry out digital transformation according to the path of "service industry → manufacturing industry → agriculture".

In short, the digital development path in the province still needs to be adapted to the local conditions, combined with the province's leading industries, and then choose the appropriate path to ultimately achieve the digital enhancement of the industry.

**Table 3.** Degree of digitalisation by industry in China, 2002-2017

| Degree of digitalisation | 2002 | 2007 | 2012 | 2017 |
|---|---|---|---|---|
| High | digital industrialization | digital industrialization | digital industrialization | digital industrialization |
| Higher | energy industry | energy industry | service industry | manufacturing industry |
| Medium | manufacturing industry | manufacturing industry | manufacturing industry | service industry |
| Lower | service industry | service industry | energy industry | energy industry |
| Low | agricultural industry | agricultural industry | agricultural industry | agricultural industry |


High level of digital industrialisation
Low level of digital industrialisation
Beijing
Shanghai
Guangdong
Jiangsu
Tianjin
Fujian
Zhejiang
Chongqing
Sichuan
Hunan
Shanxi
Anhui
Shandong
Inner Mongolia
Henan
Guangxi
Heilongjiang
Gansu
Xinjiang
Hubei
Low level of digitisation in the agricultural industry
High level of digitisation in the agricultural industry


High level of digital industrialisation
Low level of digital industrialisation
Beijing
Shanghai
Guangdong
Jiangsu
Tianjin
Zhejiang
Fujian
Chongqing
Sichuan
Hunan
Shanxi
Anhui
Shandong
Jilin
Ningxia
Inner Mongolia
Henan
Yunnan
Guangxi
Heilongjiang
Gansu
Xinjiang
Hubei
Low level of digitisation in the energy industry
High level of digitisation in the energy industry

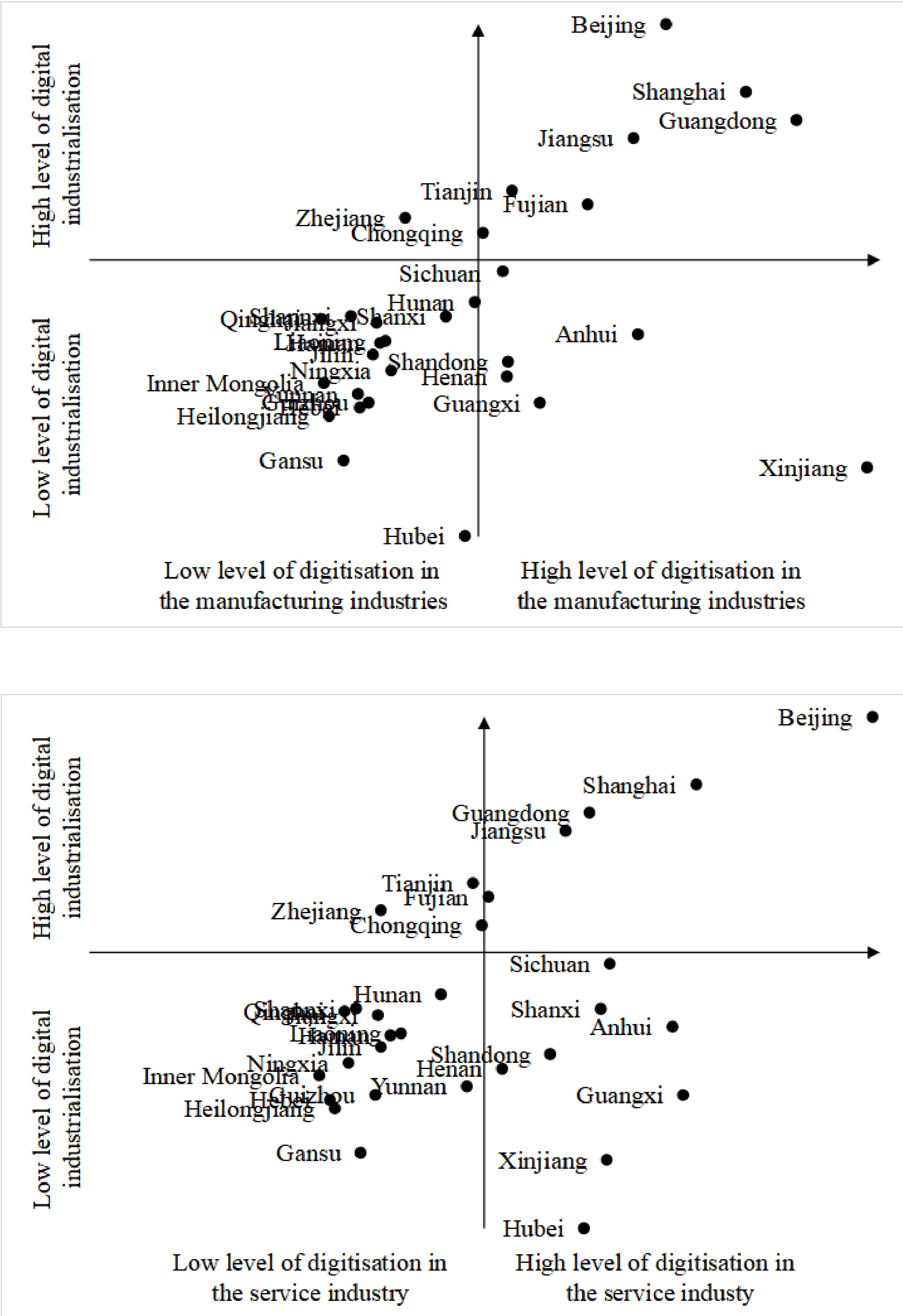



**Figure 4.** Extent of digital industrialization and digitalisation of industrial sectors by province in China, 2017

*4.2 Analysis of the Influence Coefficient and the Coefficient of Induction*

According to the concept of the influence coefficient, in the context of this paper, it is the extent to which each additional unit of end-use in the digital industry generates a ripple effect on the demand for production in various sectors of the national economy. An impact coefficient greater than 1 indicates a stronger impact on the national economy, and vice versa. Accordingly, this paper classifies China's 30 provinces, cities and autonomous regions into two categories: digital leadership (influence coefficient greater than 1) and digital catch-up (influence coefficient less than 1). What the inductance coefficient portrays in this paper is the degree of induction of the digital industry sector to the needs of economic development. Taking the average value of the inductance coefficient of 30 provinces, municipalities and autonomous regions in China in 2017 as the standard, the provinces above the average value belong to the demand-sensitive type, and the provinces below the average value are the demand-retarded type.

As can be seen from the results presented in Figure 5, for Shanxi, Yunnan, Xinjiang and other regions of the digital economy in the development of the province is relatively backward, but is classified as demand-sensitive, which may be the total economic output of these provinces is relatively high, and the existence of policies conducive to the development of the digital industry on its positive impact, resulting in its economic changes will soon bring a strong reaction of the digital industry. Some of the remaining provinces, as large digital industry provinces themselves, will naturally respond to the overall economic stimulus. In addition, provinces such as Beijing, Tianjin and Zhejiang are in the slow demand type, indicating that the degree of development of the digital industry in these provinces will not have a great impact on their economic development, analysing the reasons for this may be due to the fact that for some economically developed provinces, their digital industry is already more sound, and the development goal of these provinces has changed from the infrastructure of the digital industry to the digitalisation of other industries. For the rest of the economically underdeveloped regions, such as Inner Mongolia, Hainan, Guizhou, Qinghai, Ningxia and other regions, due to the size of the digital industry is still insufficient, while its economic volume is relatively small, for the overall economic stimulus performance will only have a weak impact on the results.

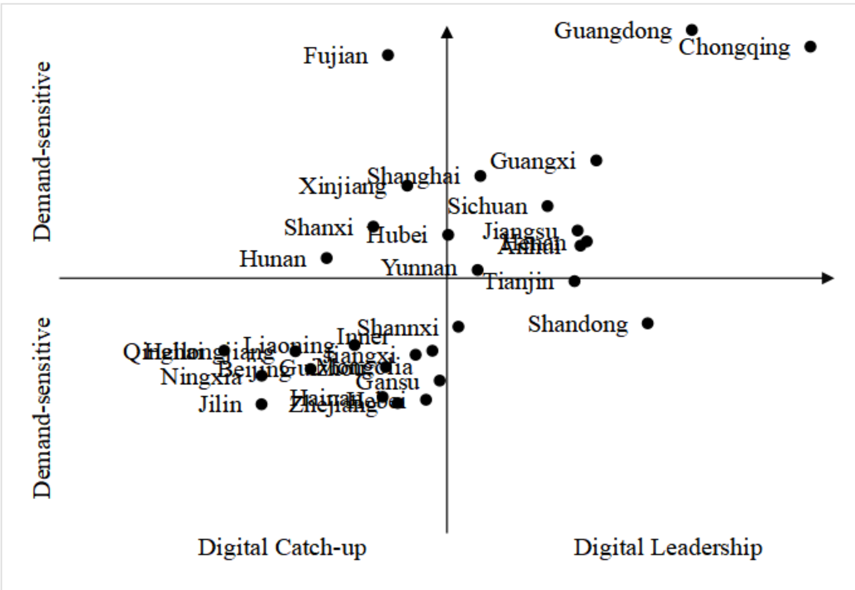



**Figure 5.** Distribution of digital industry influence coefficient and inductance coefficient type by province in China, 2017

## 5. Convergence Analysis of the Provincial Digital Economy

### *5.1 σ Convergence Analysis*

According to the σ convergence results, it can be analysed that there is σ convergence in both digital industrialization and industrial digitalisation from 2002 to 2017 on a national scale. There is convergence only in the northeast in digital industrialization, and the convergence feature is not obvious in the east; there is convergence only in the east in industrial digitalisation, and only the west in the digital economy shows divergence features.

*5.2 Absolute β Convergence Analysis*

The two-way fixed effects and random effects of the panel model were carried out in the beta convergence analysis respectively, and the fixed effects were found to be more appropriate through the Hausmann test, and the two-way fixed effects model for region and time was finally chosen.

As shown in Table 4, the results of the absolute β convergence test of digital industrialization and industrial digitalisation for the whole country and each region are reported, from which it can be intuitively seen that the convergence coefficients of digital industrialization and industrial digitalisation for the whole country are all significantly negative at the level of 1%, i.e., there is a tendency of absolute β convergence, which suggests that, under similar initial conditions, there is an accelerated catching up in the province with a lower value of efficiency, and its average growth rate will be higher than that of provinces with high efficiency values, and this phenomenon occurs in both digital industrialization and industrial digitalisation.

Specifically, the convergence of the four major economic regions in industrial digitalisation is significant at least at the 5 per cent level, with the central region showing the fastest rate of convergence and the eastern region showing the slowest rate of convergence. Combined with the previous analysis, the rest of the regions except the eastern region have relatively large internal differences, resulting in a relatively fast convergence rate, and the rate of convergence shows the characteristics of "Northeast > Midwest > East". Industrial digitalisation in the north-eastern region does not show the characteristics of absolute β convergence, but in general can be inferred from the difference between the convergence rate and the digital industrialization, showing the characteristics of the "West > East Midlands > Northeast". The reason for this opposite phenomenon with digital industrialization may be due to the penetration of the digital industry to other industries needs a certain time, the eastern region of the digital industry development started early, while the western region due to geographic reasons, the digital transformation is more difficult, resulting in the digitalisation of its industry convergence rate is slower, which is the opposite of the digital industrialization, the greater the internal differences, the slower the convergence rate.

**Table 4.** Absolute beta convergence test for digital industrialization and industrial digitalisation

| | | (1) Nationwide | (2) Eastern | (3) Northeastern | (4) Central | (5) Western |
|---|---|---|---|---|---|---|
| digital industrialization | β | -0.780*** | -0.744** | -1.421*** | -1.475*** | -1.117*** |
| | | (-5.91) | (-3.28) | (-6.33) | (-4.78) | (-4.84) |
| | Rate of convergence | 0.144 | 0.139 | 0.221 | 0.227 | 0.187 |
| | Province fixed | Yes | Yes | Yes | Yes | Yes |
| | Year fixed | Yes | Yes | Yes | Yes | Yes |
| | Adjusted $R^2$ | 0.151 | 0.025 | 0.257 | 0.001 | 0.180 |
| Industrial digitalisation | β | -1.058*** | -1.120*** | -0.608 | -1.062* | -1.319*** |
| | | (-7.42) | (-3.97) | (-0.90) | (-3.06) | (-6.80) |
| | Rate of convergence | 0.569 | 0.188 | 0.119 | 0.181 | 0.21 |
| | Province fixed | Yes | Yes | Yes | Yes | Yes |
| | Year fixed | Yes | Yes | Yes | Yes | Yes |
| | Adjusted $R^2$ | 0.184 | 0.143 | 0.327 | 0.547 | 0.240 |

Note: Values in parentheses are t-values.* p<0.05.** p<0.01.***p<0.001

*5.3 Conditional β Convergence Analysis*

The results of the conditional convergence test between digital industrialization and industrial digitalisation are shown in Table 5 below. The results show that both are significant at the 1% level in the national context, indicating that there is a clear trend of conditional convergence, which is also consistent with the conclusions obtained from absolute β convergence.

Specifically, with province fixed effects and year fixed effects, digital industrialization and industrial digitalisation will reach steady state levels at some point in the future from a national perspective. Similar to the absolute β convergence conclusion, the convergence rate of digital industrialization is still faster among the two, reaching a level of 0.203, with digital industrialization 0.177 in the next highest position. In the conditional β convergence results, the Northeast remains insignificant, indicating that it does not have conditional β convergence. The Central region is also not significant at the lowest 10% level for industrial digitalisation and digital economy, suggesting that it also does not have conditional β convergence. However, by combining the convergence of other regions, it can be seen that digital industrialization still shows the characteristics of convergence speed "inland > coastal", and the convergence speed of industrial digitalisation shows the characteristics of "coastal > inland", and the whole shows that "East > West > Central > Northeast".

From an overall perspective, digital industrialization should focus more on the development of inland areas and strengthen the digital industry support for inland areas; industrial digitalisation should focus on the digital upgrading of industries in coastal areas, and apply some of the transformation experience to the inland; the digital economy is an assessment of the overall level of digital development, and it can be seen that the coastal provinces will be better than the inland provinces, which will ultimately affect the overall development trend of the digital economy through the adjustments of digital industrialization and industrial digitalisation.

**Table 5.** Conditional β convergence test for digital industrialization and industrial digitalisation

| | | (1) nationwide | (2) Eastern | (3) Northeastern | (4) Central | (5) Western |
|---|---|---|---|---|---|---|
| digital industrialization | β | -1.030*** | -0.634* | -0.625 | -1.152* | -1.463*** |
| | | (-7.51) | (-2.46) | (-2.38) | (-4.14) | (-6.95) |
| | Rate of convergence | 0.177 | 0.123 | 0.121 | 0.192 | 0.225 |
| | Control variables | Yes | Yes | Yes | Yes | Yes |
| | Province fixed | Yes | Yes | Yes | Yes | Yes |
| | Year fixed | Yes | Yes | Yes | Yes | Yes |
| | Adjusted R2 | 0.134 | 0.037 | 0.727 | 0.000 | 0.058 |
| Industrial digitalisation | β | -1.248*** | -1.491*** | -0.322 | -1.617 | -1.335*** |
| | | (-9.36) | (-6.17) | (-0.11) | (-1.07) | (-5.37) |
| | Rate of convergence | 0.203 | 0.228 | 0.070 | 0.241 | 0.212 |
| | Control variables | Yes | Yes | Yes | Yes | Yes |
| | Province fixed | Yes | Yes | Yes | Yes | Yes |
| | Year fixed | Yes | Yes | Yes | Yes | Yes |
| | Adjusted R2 | 0.283 | 0.049 | 0.623 | 0.218 | 0.197 |

Note: Values in parentheses are t-values.* $p<0.05$.** $p<0.01$.***$p<0.001$

## 6. Conclusions

This paper measures the scale of digital industrialization and industrial digitalisation in 30 Chinese provinces from 2002 to 2017 based on the input-output table, and applies Kernel density estimation, Dagum Gini coefficient, and economic convergence model to analyse the evolution dynamics, industrial association characteristics and their convergence.

The main conclusions are as follows: (1) The overall level of China's digital economy development presents a pattern of developed coastal areas and underdeveloped inland areas. Coastal areas have more obvious advantages in digital economy development compared with inland areas. According to the indicators of per capita digital economy development and the results of the economic convergence model, in terms of regions, the eastern and western regions have absolute β convergence and conditional β convergence characteristics in digital industrialization and industrial digitalisation, the north-eastern region has absolute β convergence only in digital industrialization, and the central region has absolute β convergence but conditional β convergence only in digital industrialization. The conditional β convergence exists in digital industrialization, and the overall convergence speed shows the characteristic of "East > West > Central > Northeast"; (2) the dynamic change of the difference between the provinces in the inland region changes from small to large, especially in the central and western regions, which is the most obvious. The results of the Kernel density estimation and the Dagum Gini coefficient show that most of the gap indigital economic development comes from inter-regional differences. Most of the economic development gap comes from inter-regional differences, but the influence degree is gradually shrinking, and the influence from within the region is gradually expanding; (3) According to the path of China's industrial digital development, "energy industry → service industry → manufacturing industry → agriculture". Based on the province's leading industries, strengthen the weak industries, combine the leading industries with the industrial development path, formulate corresponding strategies according to local conditions, and ultimately achieve the overall efficiency improvement of industrial digitalisation.

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