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# A Study of the Impact of China's Digital Infrastructure on Coordinated Regional Economic Development

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***Abstract:*** This paper centers on the theme of "Research on the impact of China's digital infrastructure on the coordinated development of regional economy", and systematically analyzes the role of digital infrastructure in the economic development of China's regions and its influence mechanism. the impact of digital infrastructure on the coordinated development of regional economy is explored in depth using coupled model and linear regression analysis. It is found that mobile Internet access traffic, as an important indicator of digital infrastructure, has a significant positive impact on regional economic development, while the negative correlation between the market volume of technological transactions and GDP needs to be further analyzed. Finally, the article looking forward to the potential and prospects of digital infrastructure in promoting coordinated regional economic development.

***Keywords:*** digital infrastructure, coordinated regional economic development, mobile Internet access traffic, coupled model

## 1. Introduction

Driven by the current wave of global informatization, digital infrastructure has become a core element of contemporary economic development, and its importance has become increasingly prominent. Digital infrastructure, as a comprehensive system of hardware, software and services supporting the development of the digital economy, has been likened to the "digital nervous system" of a country or region. Meanwhile, as a core element of contemporary economic development, its definition and type have a broad consensus in both academia and practice. Generally speaking, digital infrastructure is understood as a series of hardware and services that support the development of the digital economy, which together constitute the digital nervous system of a country or region, and play a crucial role in facilitating the flow of information, optimizing the allocation of resources, innovating business models and enhancing social efficiency [1].

Through in-depth research on the impact of China's digital infrastructure on the coordinated development of the regional economy, this study can enrich and develop the theoretical systems of digital economics, regional economics, and economic geography and other related disciplines.

It helps to reveal the internal logic and law of digital infrastructure on the coordinated development of regional economy. The development of digital infrastructure has not only changed the mode and speed of information dissemination, but also profoundly affected the allocation efficiency of resources, the organization of industries and the competitive pattern of regional economy [2].

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## 2. Literature review and hypothesis formulation

The development of digital infrastructure has promoted the flourishing of the digital economy and injected a strong impetus into the coordinated development of regional economies. In China, the continuous improvement of digital infrastructure has led to a smoother flow of information and broken down the information barriers between regions. At the same time, the emergence of digital economic platforms has promoted the optimal allocation of resources, and enterprises in different regions can achieve more accurate matching of supply and demand through these platforms to improve the efficiency of resource utilization, which in turn promotes the synergistic development of the regional economy [3]. In addition, the new business models and formats spawned by the digital economy, such as the sharing economy and the zero-work economy, provide more economic development opportunities for regions, promote the diversified development of the regional economy, and are conducive to narrowing the economic gap between regions and realizing the coordinated development of the regional economy.

H1: Digital economy for coordinated regional economic development

The construction of digital infrastructure provides solid support for the development and application of cutting-edge technologies, which in turn indirectly promotes the coordinated development of regional economies. In China, with the rapid development of frontier technologies such as 5G, artificial intelligence and big data, the digital economy has been upgraded continuously. On the one hand, the upgrading of cutting-edge technologies has promoted the digital transformation of industries [4]. Manufacturing enterprises realize intelligent production and refined management with the help of AI and big data technologies, improve production efficiency and product quality, enhance industrial competitiveness, and promote the upgrading and development of industries in the region. On the other hand, the upgrading of cutting-edge technologies promotes the enhancement of regional innovation capacity. Research institutions and enterprises are able to utilize advanced digital infrastructure and technological means to carry out wider scientific cooperation and technological innovation activities and accelerate the transformation of scientific and technological achievements.

H2: The digital economy indirectly contributes to coordinated regional economic development through cutting-edge technological upgrading

The economies of China's regions are closely linked, and the digital economy has obvious spatial relevance in the regional economic system. The development of digital infrastructure makes the spatial spillover effect of the digital economy more significant [5]. First, the spatial spillover of knowledge and technology. In the era of digital economy, the speed of knowledge and technology dissemination is accelerated, and the advanced experience and technological achievements made by a region in the construction of digital infrastructure and the application of digital technology can be rapidly disseminated to the neighboring regions through the Internet, personnel exchanges, and other means. Second, the spatial spillover of industrial transfer and synergy. The improvement of digital infrastructure reduces the operating costs of enterprises and market transaction costs, making the transfer of industries between regions smoother. Finally, the spatial overflow of market integration.

H3: The digital economy has spatial spillover effects on coordinated regional economic development

## 3. Variable settings

In this paper, the period of 2013-2022 was selected as the research period, and the data for the explanatory variables were obtained from the records of the National Bureau of Statistics, and the data required for the control variables and explanatory variables were obtained from the China Statistical Yearbook and the Ministry of Industry and Information Technology; at the same time, in

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order to ensure the uniformity of the study and the quality of the data, a total of 31 provinces in China were selected as the research samples for the study.

### 3.1. Dependent variable - level of digital infrastructure development

Indicators such as the Internet penetration rate, the number of mobile base stations, and the number of servers in data centers are used to assess the development level of digital infrastructure. In this study, with reference to the selected subjects and research objects, the number of Internet broadband access users, cell phone penetration rate, the length of long-distance fiber optic cable lines, and the number of artificial intelligence enterprises are selected as proxy variables for digital infrastructure, and their comprehensive indicators are calculated using the entropy method.

### 3.2. Dependent variable - level of coordinated regional economic development

It is measured by indicators such as per capita GDP growth rate, industrial structure optimization index, employment rate, innovation index and regional economic gap coefficient. According to the selected topic and research direction, this paper selects the population size, total import and export, GDP per capita, gross regional product and urban-rural income gap of each province as proxy variables to be analyzed.

### 3.3. Control variable

Gross regional product (GDP): this study measures this variable by calculating the sum of the market value of all final goods and services produced by each province in a given period of time.

Government Fiscal Expenditure (GFE): refers to monetary expenditures made by the government to fulfill its functions. In this study, total regional fiscal expenditure as a share of GDP for the year is used as a measure.

Fixed Asset Investment (FAI) in each province: refers to the monetary expenditures made by each province for the purchase or construction of fixed assets (e.g., plant, equipment, dwellings, etc.) over a given period of time. This study measures this by calculating the amount of fixed asset investment in a region as a percentage of GDP.

Labor Costs by Province (LCT): refers to the average salary level or unit labor costs in the labor market within each province. In this study, the salary, benefits, taxes and other expenditures of each employee are combined in order to calculate the labor cost used in each province.

Per Capita Consumption by Province (PCC): refers to the sum of the value of goods and services consumed per capita by residents of each province over a certain period of time. This study takes the region's total retail sales of consumer goods as a share of GDP as a measure.

## 4. Empirical research and analysis

### 4.1. Coupled modeling

In the empirical research, the coupled model construction and variable selection is a crucial part, while the relevant formulas and introductions of the coupled model are the basis for the construction of the model. The following is a detailed list of the relevant formulas and introductions of the coupled model:

(1) Coupling degree formula

BASIC FORM: The coupling degree C is commonly used to measure the degree of interaction between elements within a system. A commonly used coupling degree formula is:

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$$\frac{3\times(\prod_{i=1}^{n} X_i)}{\sum_{i=1}^{n} X_i} \tag{1}$$

Where $X_i$ represents the indicator value of the ith element and n is the number of elements. This formula reflects the degree of coupling between elements by calculating the ratio of the geometric mean to the arithmetic mean of the indicator values of each element.

(2) Coupling coordination degree formula

Definition: coupling coordination degree D is a combination of coupling degree and coordination index, which is used to assess the overall level of coordinated development between systems.

$$\text{Equation: } D = C\times T \tag{2}$$

where C is the coupling degree and T is the coordination index. The coordination index T is usually calculated by the following formula:

$$T = \frac{C+C_{min}}{C_{max}+C_{min}} \tag{3}$$

where $C_{min}$ and $C_{max}$ represent the minimum and maximum values of the coupling coefficient, respectively.

## 4.2. Empirical results and analysis

### 4.2.1. Descriptive statistical analysis

Table 1: Descriptive statistical analysis of economic development data of national provinces

| variable name | sample size | maximum values | minimum value | average value | (statistics) standard deviation | upper quartile | variance (statistics) | kurtosis | skewness | coefficient of variation |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 310 | 53.98 | 0.162 | 11.617 | 17.609 | 0.47 | 310.094 | -0.81 | 1.022 | 1.516 |
| financial expenditure | 310 | 18509.9 | 922.48 | 5708.787 | 3182.37 | 5090.7 | 10127481.86 | 2.272 | 1.242 | 0.557 |
| fixed-asset investment | 310 | 65087.935 | 876.002 | 20853.013 | 15406.944 | 16173.591 | 237373919.6 | -0.152 | 0.847 | 0.739 |
| human capital | 310 | 0.044 | 0.009 | 0.021 | 0.006 | 0.021 | 0 | 1.192 | 0.651 | 0.278 |
| Per capita consumption | 310 | 78500 | 17781 | 36143.4 | 11150.772 | 34211.5 | 124339707 | 1.604 | 1.185 | 0.309 |
| Mobile Internet access traffic | 310 | 3431672.7 | 527.94 | 382132.815 | 504547.268 | 186323.5 | 2.54568E+11 | 7.395 | 2.316 | 1.32 |
| Local revenues | 310 | 14105.04 | 124.27 | 3141.256 | 2642.991 | 2356.08 | 6985399.865 | 3.245 | 1.723 | 0.841 |
| foreign trade | 310 | 1276590000 | 310532 | 155178488.3 | 243813794.4 | 54308718.5 | 5.94452E+16 | 5.964 | 2.439 | 1.571 |
| volume of freight | 310 | 434298 | 1914 | 153158.374 | 102941.903 | 154170.5 | 10597035396 | -0.285 | 0.559 | 0.672 |
| Market volume of technology transactions | 310 | 8536.94 | 0.04 | 799.862 | 1336.9 | 227.085 | 1787301.676 | 9.019 | 2.782 | 1.671 |

According to the descriptive statistical analysis in Table 4-1, this study professionally analyzes the economic development data of 31 provinces and cities in China in the past ten years as follows:

(1) Mobile Internet access traffic

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Sample size and scale: The sample size is 310 and the mean value is 382132.815, showing a high level of mobile Internet access traffic. Volatility: The standard deviation is 504547.268, indicating significant differences in mobile Internet access traffic among provinces and cities. The coefficient of variation (CV) is 1.32, indicating a relatively large fluctuation of mobile Internet access traffic. Shape characteristics: the kurtosis is 7.395 and the skewness is 2.316, indicating that the mobile Internet access traffic data may have an extremely right-skewed distribution with an extremely thick tail.

(2) Local revenues

Sample size and size: the sample size is 310 and the mean value is 3141.256, showing a high level of local financial revenue. Volatility: The standard deviation is 2,642.991, indicating that the local fiscal revenues of provinces and cities vary greatly. The coefficient of variation (CV) is 0.841, indicating a relatively large volatility of local fiscal revenues. Shape characteristics: the kurtosis is 3.245 and the skewness is 1.723, indicating that the data on local fiscal revenues may have a right-skewed distribution with thicker tails.

(3) Foreign trade

Sample size and size: the sample size is 310 and the mean is 155178488.3, showing a high level of foreign trade. Volatility: The standard deviation is 243813794.4, indicating that foreign trade varies greatly among provinces and cities. The coefficient of variation (CV) is 1.571, which also confirms the high volatility of foreign trade. Shape characteristics: the kurtosis is 5.964 and the skewness is 2.439, indicating that the foreign trade data may have an extremely right-skewed distribution with extremely thick tails.

(4) Cargo volume

Sample size and size: the sample size is 310 and the mean value is 153158.374, showing a high level of freight volume. Volatility: The standard deviation is 102941.903, indicating a high level of variation in freight volume across provinces and cities. The coefficient of variation (CV) is 0.672, indicating that the volatility of freight volume is relatively moderate. Shape characteristics: the kurtosis is -0.285 and the skewness is 0.559, indicating that the freight volume data may be slightly right-skewed, but the tails are close to normal distribution.

(5) Market volume of technology transactions

Sample size and size: the sample size is 310 and the mean value is 799.862, indicating a low level of technology transaction market volume. Volatility: The standard deviation is 1,336.9, indicating that the market volume of technology transaction varies greatly among provinces and cities. The coefficient of variation (CV) is 1.671, indicating that the volatility of the technology transaction market volume is large. Shape characteristics: the kurtosis is 9.019 and the skewness is 2.782, indicating that the data on the market volume of technology transactions may have an extremely right-skewed distribution with an extremely thick tail. Economic variability: From the standard deviation and coefficient of variation of each indicator, there are significant differences in the economic development of the 31 provinces and cities across the country. Such differences may stem from a variety of factors such as geographic location, resource endowment, and policy environment.

### 4.2.2. Reliability analysis

Table 2: economic development reliability analysis by province and city, 2014-2023

| Cronbach's alpha coefficient | Standardized Cronbach's alpha coefficient | item count (of a consignment etc) | sample size |
|---|---|---|---|
| 0.003 | 0.89 | 10 | 310 |

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The Cronbach's alpha coefficient given in Table 4-2 is 0.003, which indicates that there is little internal consistency between these 10 economic indicators in the economic development data of the provinces and cities for the period 2014-2023, i.e., the correlation between these indicators is very weak. The standardized Cronbach's alpha coefficient is 0.89, which is a relatively high value. The standardized Cronbach's alpha coefficient is calculated after standardizing the raw data, which eliminates the effects of different indicator scales and orders of magnitude. The coefficient indicates that the 10 economic indicators show a high degree of internal consistency with each other after eliminating the effects of the scale and order of magnitude.

### 4.2.3. Validity analysis

Table 3: KMO test and Bartlett's test table

| | | |
|---|---|---|
| KMO value | | 0.802 |
| Bartlett's test of sphericity | approximate chi-square (math.) | 3524.388 |
| | df | 55 |
| | P | 0.000*** |

Note: ***, **, * represent 1%, 5%, and 10% significance levels, respectively.

Table 4-3 validity results show that the high KMO values indicate that these indicators are suitable for factor analysis and can be processed by dimensionality reduction to extract the main economic factors.The significance results of the Bartlett's test of sphericity further support the conclusion that there is a correlation between the variables.

### 4.2.4. Coupling analysis (physics)

Based on the content of the data (table omitted due to space limitation), this study conducts the following specific analyses around the theme of "Research on the Impact of China's Digital Infrastructure on the Coordinated Development of Regional Economies":

(1) Relationship between digital infrastructure and coupling C-value

Overall Trend and Regional Differences: It can be seen from the data that the coupling C-value is generally higher in economically developed regions, which is related to the more perfect digital infrastructure in these regions. The improvement of digital infrastructure promotes the efficient flow of information and the optimal allocation of resources, thus enhancing the degree of interaction and interdependence between the elements within the economic system. In contrast, less economically developed regions have lower coupling degree C values, which may be related to the relative backwardness of their digital infrastructure. Inadequate digital infrastructure limits the efficient circulation of information and allocation of resources, thus affecting the degree of coordination among the elements within the economic system.

(2) Relationship between digital infrastructure and the T-value of the harmonization index

Extreme values and regional differences: Extreme values of the Harmonization Index T-value in some regions may be related to localized uneven development of digital infrastructure. For example, some regions may have increased their investment in digital infrastructure in certain years, leading to significant changes in certain economic indicators, which may affect the Harmonization Index T-value. Economically developed regions generally have higher harmonization index T-values, which may be related to more balanced digital infrastructure development in these regions. Balanced digital infrastructure development helps to maintain stability and coordination among the elements within the economic system.

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(3) Relationship between digital infrastructure and coupling coordination degree D-value and coordination level

Overall level and regional differences: Most regions have a high D value for coupling harmonization and are rated as "high quality harmonization" or "good harmonization", which may be related to the relatively well-developed digital infrastructure in these regions. The improvement of digital infrastructure facilitates the close connection and interaction between the elements within the economic system, thus improving the overall coordination and competitiveness. Less economically developed regions have relatively lower coupling coordination degree D values and coordination grades, which may be related to their relatively poor digital infrastructure. The lack of digital infrastructure limits the coordinated development of the regional economy.

### 4.2.5. Linear regression analysis

Table 4: Linear regression analysis results

| | Non-standardized coefficient | | Standardized coefficient | t | P | VIF | $R^2$ | Adj. $R^2$ | F |
|---|---|---|---|---|---|---|---|---|---|
| | B | standard error | Beta | | | | | | |
| a constant (math.) | -0.61 | 0.055 | - | -11.029 | 0.000*** | - | 0.961 | 0.958 | F=356.66 P=0.000*** |
| human capital | 0.028 | 0.016 | 0.028 | 1.692 | 0.092* | 1.978 | | | |
| freight volumes | 0.054 | 0.022 | 0.054 | 2.397 | 0.017** | 3.739 | | | |
| Standardized unemployment rate | -0.055 | 0.02 | -0.055 | -2.78 | 0.006*** | 2.956 | | | |
| mobile Internet access traffic | 0.13 | 0.03 | 0.13 | 4.338 | 0.000*** | 6.706 | | | |
| market volume for technology transactions | -0.088 | 0.019 | -0.088 | -4.572 | 0.000*** | 2.736 | | | |
| foreign trade | -0.149 | 0.049 | -0.149 | -3.057 | 0.002*** | 17.537 | | | |
| local revenues | 0.262 | 0.081 | 0.262 | 3.22 | 0.001*** | 49.009 | | | |
| Standardized per capita consumption | -0.016 | 0.029 | -0.016 | -0.535 | 0.593 | 6.399 | | | |
| investment in fixed assets | 0.021 | 0.027 | 0.021 | 0.785 | 0.433 | 5.328 | | | |
| financial expenditures | -0.153 | 0.062 | -0.153 | -2.467 | 0.014** | 28.502 | | | |
| particular year | YES | | | | | | | | |
| provinces | YES | | | | | | | | |

Based on the results of the linear regression analysis, we can deeply analyze the degree of influence of digital infrastructure on regional economic development. The following is an analysis of the relevant variables and their relationship with regional economic development:

(1) Analysis of variables related to digital infrastructure

Standardization of mobile Internet access traffic:

Standardized coefficient (Beta): 0.13, indicating a positive correlation between mobile internet access traffic and GDP. And the P-value is 0.000***, indicating that the impact of this variable on GDP is highly statistically significant. The increase in mobile Internet access traffic indicates the improvement of digital infrastructure, which promotes the flow of information and the optimal allocation of resources, thus promoting the development of the regional economy.

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(2) Standardization of market volume for technology transactions:

Standardized coefficient (Beta): -0.088, indicating a negative correlation between the market volume of technology transactions and GDP, but this is not in line with conventional expectations and may require further analysis. Although the standardized coefficient is negative, an increase in the market volume of technology transactions is usually seen as a positive sign of technological innovation and economic development. This negative correlation may need to be interpreted in the context of other factors, such as an increase in the volume of technology exchanges that may reflect an increase in the cost of technology introduction or the efficiency of technology transformation.

## 5. Conclusion

Governments should significantly increase investment in digital infrastructure, especially in less economically developed regions. Through financial allocations, tax incentives, policy support and other means, social capital should be encouraged to participate in the construction of digital infrastructure to form a diversified investment pattern. In view of the significant positive impact of mobile Internet access traffic on regional economic development, the government should further increase the construction and optimization of mobile communication networks to improve mobile Internet coverage and speed. At the same time, it should encourage and support the development of mobile Internet-related industries and promote the widespread application of mobile Internet in the regional economy. Formulate a scientific and reasonable digital infrastructure development plan, with clear development goals, key tasks and safeguard measures. Ensure that the plan is forward-looking and operable, and can lead the balanced development of digital infrastructure.

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