The Impact of the Driving Role of Central Cities on Regional Coordinated Development under the Background of Digital Economy

Chen,Lingfeng Xue,Jia-ning

Beijing Wuzi University, Beijing, 101149, China

Abstract: In the context of the digital era, the digital economy, as a new form of economic structure, is gradually becoming the core driving force for high-quality economic development and exerting a profound impact on coordinated regional development. This paper aims to explore how the digital economy influences regional coordinated development through the driving effect of central cities, as well as the mechanisms and pathways of this influence.

Keywords: Digital economy; Central city driving effect; Regional coordinated development

DOI: 10.62639/sspjiss10.20250201

1. Introduction

(1) Research background and significance

Regional development imbalance is a common issue faced by countries in the process of modernization. This will further highlight the comparative advantages of regions in developing new productive forces according to local conditions, improve the level of regional cooperation, innovate regional mutual assistance mechanisms, expand regional development space, and enhance the balance and coordination of regional development on the basis of continuously improving the quality of regional development.

(2) Literature review

As the core of the region, the central city has significant economic, political, cultural and social influence. Its development plays an important role in promoting the overall progress of the surrounding areas and countries. The formation of urban agglomerations is essentially a process of continuous strengthening of inter-city connections. Growth pole theory, cyclic cumulative causality theory, center-periphery theory, point-axis theory and so on show that once the growth pole is formed, it will have polarization effect and diffusion effect on the periphery[1] (Myrdal, 1957). As the growth pole of urban agglomeration, the central city has three effects on its periphery : positive effect, negative effect and neutral effect[2] (Wei, 2011). The positive effect is diffusion, and the negative effect is polarization. The comprehensive effect is called driving effect, which depends on the intensity of polarization and diffusion. The role of central cities in the economic development of urban agglomerations is mainly reflected in the development of infrastructure, opening up and collaborative innovation. National central cities can effectively promote the overall development of urban agglomerations, but the driving effects between different urban agglomerations are different. The mechanism of action includes network connection, factor flow and market inclusion, and the main mechanism of action of different urban agglomerations is different[3] (Liu Zhiyan et al., 2023).

The central city has a strong agglomeration function and radiation effect, which is not only an important

(Manuscript NO.: JISS-25-1-62006)

About the Author

Chen,Lingfeng (2000-), male, Han, Guangdong Jieyang, Master degree, no, Political economics.
Xue,Jia-ning (1998-), male, Han, Beijing, Master degree, no, Western economics.

growth pole to promote regional economic development, but also an engine to promote regional coordinated development[4] (Mao Yanhua et al., 2021). Central cities can attract and concentrate resources, promote the rational flow and optimal allocation of production factors such as capital, technology and talents in the region through market mechanisms and policy guidance, and promote coordinated regional development . Central cities usually have strong innovation capabilities and high-tech industries, which can drive the upgrading and transformation of industrial structure in surrounding areas and improve the overall competitiveness of regional industries[5] (Wang et al., 2022). Central cities have advantages in infrastructure construction such as transportation and communication, which can improve inter-regional connectivity, reduce logistics costs, and improve the overall efficiency of the regional economy. This agglomeration effect not only enhances the city 's innovation ability, but also drives the integrated development of regional economy.

2. Influence Mechanism

(1) The direct impact of the leading role of the central city on the coordinated development of the region

The leading role of central cities in regional coordinated development is multifaceted, mainly reflected in the following aspects :

First, the driving effect of central cities on regional economic growth is mainly reflected in their industrial agglomeration and diffusion effects.Second, industrial upgrading and structural optimization are the key ways for central cities to promote regional economic development. Third, the improvement of infrastructure and public services is the key means for central cities to promote regional coordinated development.

Hypothesis 1 : The leading role of central cities contributes to regional coordinated development.

(2) The indirect influence of the leading role of central cities on regional coordinated development

Central cities play a vital role in promoting regional coordinated development. They usually have a more developed economy, rich resources and high innovation ability, and can play a positive role in the surrounding areas in a variety of ways.

Hypothesis 2 : The driving role of central cities can promote regional coordinated development through innovation and human capital.

3.Index Measurement and Characteristic Analysis

In order to explore the impact of the driving role of central cities on regional coordinated development under the background of digital economy, this paper measures and analyzes the driving role and regional coordinated development level of central cities at the prefecture level and above in Beijing-Tianjin-Hebei, Yangtze River Delta and Guangdong-Hong Kong-Macao urban agglomerations from 2011 to 2020. By constructing a scientific and reasonable evaluation index system, the driving role of central cities and the level of regional coordinated development under the background of digital economy are accurately measured, and the influence mechanism of the two is deeply explored.

(1) Measurement of the driving effect index of central cities

In the context of the rapid development of the digital economy, central cities are playing an increasingly important role in promoting regional economic growth and social progress. In order to comprehensively measure the leading role of central cities in this process, based on the existing research results, this paper draws on the evaluation index system of the comprehensive strength of Chinese prefecture-level cities developed by the City

Department of the National Bureau of Statistics and the Research Group of the Urban Statistics Branch of the China Statistical Association, and extracts and focuses on the relevant indicators related to the development of urban driving force. A multi-dimensional index system is constructed from four aspects: urban digital development, urban openness, urban quality of life and urban industrial structure.

The system not only covers the impact of the economic level, but also involves many aspects such as social development, which provides a scientific basis for the systematic analysis of the driving role of the central city.

Tab 1 Evaluation of driving effect index of central city

Dimension	First-level index	Second-level index	Nature
Urban digital development	Internet penetration rate	Number of Internet users per 100 people	+
	Number of Internet-related employees	Proportion of computer service and software practitioners	+
	Internet-related output	Per capita total telecommunications business	+
	Number of mobile Internet users	Number of mobile phone users per 100 people	+
	Inclusive development of digital finance	Inclusive Financial Index	+
Urban openness	Total import and export value	Total import and export	+
	The actual use of foreign investment	The actual use of foreign direct investment	+
Urban quality of life	Income level of residents	Average wage of on-the-job workers	+
	Living standards of residents	Per capita disposable income of rural residents	+
		Per capita disposable income of urban residents	+
Urban industrial structure	Industrial optimization	Gross output value of tertiary industry	+
	Industrial development	The added value of tertiary industry	+

(2) Measurement of regional coordinated development index

The Atkinson index is used to calculate the regional coordinated development index.The index provides a scientific basis for regional policy formulation, helps to optimize policy implementation strategies, and promotes the coordinated and balanced development of regional economy.

Formula：

$$\mathrm{Cdr} = \left|1 - \frac{\mathrm{PGDPit}}{\mathrm{PGDP.t}}\right|$$

In this formula, PGDPit represents the per capita GDP of region *i* in period *t*, while PGDP.t is the weighted average per capita GDP of all regions in the same period.

Through the formula, we can calculate the deviation degree of per capita GDP in each region relative to the overall economic level. The Atkinson index ranges from 0 to 1, where 0 indicates that the per capita GDP of the region is completely consistent with the overall economic level, that is, the degree of coordinated economic development is the highest ; and 1 indicates that there is the greatest difference between the per capita GDP and the overall economic level in the region, that is, the lowest degree of coordinated economic development.

4. Authentic Proof Analysis

(1) Variable selection and data description

1) Variable selection

This section analyzes the direct effect of central cities on regional coordinated development and its indirect effect through scientific and technological innovation and human capital according to the third chapter index system. This paper chooses the following variables for research :

① Explained variable : the level of regional coordinated development (Y_{it})

The level of regional coordinated development measures the comprehensive development of a region in terms of economy, society and environment, reflecting the narrowing degree of development differences among regions. This paper constructs the variable based on multi-dimensional indicators, covering economic growth and social development.

② Explanatory variables : the leading role of the central city (X_{it})

The leading role of the central city is to measure the radiation and promotion of the central city to the surrounding areas in terms of economy, industry and technology diffusion.

③ Intermediary variables : technological innovation and human capital are selected as intermediary variables to analyze their indirect effects between the driving role of central cities and regional coordinated development.

Technological innovation (K_{it}) : Technological innovation capability may have a positive impact on regional coordinated development by promoting technological progress and industrial upgrading. This paper uses the number of patent applications, the number of high-tech enterprises and other indicators to measure.

Human capital (Ca_{it}) : High-quality human capital helps to enhance the region 's economic competitiveness and coordinated development capabilities. This paper measures it through indicators such as education level and labor productivity.

④ Control variable (Z_{it})

In order to control other factors that may affect the coordinated development of the region, this paper introduces the following control variables :

Fiscal expenditure and investment (Iv_{it}) : The government 's fiscal expenditure and infrastructure investment can effectively promote regional economic activities and infrastructure construction. Therefore, this paper controls the proportion of fiscal expenditure in GDP and the level of infrastructure investment.

The proportion of fiscal revenue (R_{it}) : The process of the proportion of fiscal revenue has a wide impact on many aspects such as economic structure, resource allocation and labor market. Therefore, this paper controls the proportion of fiscal revenue.

2) Data sources

The panel data used in this paper mainly come from the National Bureau of Statistics, the annual statistical yearbooks of various regions, as well as the ' *China Statistical Yearbook on Science and Technology* ', ' *China Education Statistical Yearbook* ' and other related yearbooks. The time span of the data is from 2011 to 2020, covering long-term panel data in multiple regions. Through the above variable selection and data description, this paper will be able to comprehensively analyze the direct effect of central cities on regional coordinated development and its indirect effect through technological innovation and human capital. The following table is descriptive statistics of variables.

	Variable	Obs	Mean	Std.dev.	Min	Max
Explained variable	the level of regional coordinated development (Y_{it})	180	0.1554	0.0728	0.0357	0.385
Explanatory variables	the leading role of the central city (X_{it})	180	0.3204	0.2403	0.0152	0.9694
Control variable	Fiscal expenditure and investment (Iv_{it})	180	4835	2225	1352	12779
	The proportion of fiscal revenue (R_{it})	180	0.1516	0.0314	292.596	0.2273
Intermediary variables	Technological innovation (K_{it})	180	0.1517	0.0314	0.097	0.227
	Human capital (Ca_{it})	180	0.3204	0.2403	0.02	0.969

(2) Benchmark regression analysis

1) Analysis of regression results

In order to eliminate the possible reverse causality problem, this section draws on the method of Xie et al. (2018

) for regression analysis. In addition, in order to avoid missing the influence of other regional characteristic variables on the regression results, the individual fixed effect model is used to regress the panel data.

$$Y_{it} = \partial + \beta X_{it} + \gamma_1 lv_{it} + \gamma_1 R_{it} + \mu_i + \in_{it}$$

Among them, *i* represents the region, *t* represents the year, μ_i is the unobservable regional effect, $\in_{it}$ is the random disturbance term, Y_{it} represents the regional coordinated development index, X_{it} is the driving force of the central city, lv_{it} is the proportion of fiscal expenditure to GDP and the level of infrastructure investment, and R_{it} is the fiscal expenditure rate.

In this paper, stata 15.0 is used to regress the panel data from 2011 to 2020, and the results are shown in the table.

	Y
X	-0.0517* （-2. 60）
lv	-0.0000158*** (-10.28)
R	0.00527 (0.09)
_cons	0.253*** (23.66)
N	180

t statisatics in paraentheses

* p<0.05, **p<0.01,***p<0.001

The results show that the driving force of central cities has a significant negative effect on regional coordinated development, which may be due to the excessive concentration of resources and the unreasonable industrial structure of central cities. In Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong, Hong Kong and Macao and other regions, central cities such as Beijing, Shanghai and Guangzhou often attract a large number of talents, capital and high-end industrial resources, resulting in excessive concentration of resources in central cities and uneven distribution of resources within the region, which further aggravates the economic gap between central cities and surrounding areas. In addition, the industrial division of labor between the central city and the surrounding areas is unreasonable, and the high-end industries are concentrated in the central city, while the surrounding areas rely on traditional industries, resulting in lagging regional coordinated development and negative impact.

2) Robust analysis

In order to test the robustness of the model, this study replaces the index originally used to measure ' central city driving force ' with urban GDP (X_{gdp}) as a new independent variable for regression analysis. Urban GDP is an important index to measure the vitality and scale of urban economy, which can reflect the core position of cities in regional economy. Therefore, using GDP instead of ' central city driving force ' can test whether the estimation results of the original model are robust. The test results are shown in the following table, through the robustness test.

	Y
X_{gdp}	-0.0806* （-3. 15）
lv	-0.000016*** (-12.62)
R	0.340 (1.12)
_cons	-1.598*** (-22.57)
N	180

t statisatics in paraentheses

* p<0.05, **p<0.01,***p<0.001

3) Regional heterogeneity analysis

	Yj	Yc	Yy
Xj	-0.0881** (-3.38)		
Xc		-0.0641* (-2.59)	
Xy			-0.0642* (-2.43)
Iv	-0.00000107*** (-7.02)	-0.000000176*** (-16.72)	-0.000000266*** (-6.23)
R	0.238* (2.22)	0.0000001 (.)	-0.0366 (-0.31)
_cons	0.150*** (-22.57)	0.248*** (33.31)	0.342*** (12.39)
N	60	60	60

t statisatics in paraentheses

* p<0.05, **p<0.01,***p<0.001

Analyze the regional heterogeneity of the three regions of Beijing-Tianjin-Hebei, Yangtze River Delta and Guangdong-Hong Kong-Macao, and specifically explore the response of these regions under different variables through regression analysis. The following is a summary of the analysis results:

The coefficient of the Beijing-Tianjin-Hebei region (Y_j) is-0.0881, which is significant at the 1 % level, indicating that the urban driving capacity has a significant impact on the coordinated development of the Beijing-Tianjin-Hebei region. The coefficient of the Yangtze River Delta region (Y_c) is-0.0641, and it is significant at the 5 % level, indicating that the urban driving capacity has a significant impact on the regional coordinated development of the Yangtze River Delta. In the Guangdong-Hong Kong-Macao region (Y_y), the coefficient is – 0.0642, and is significant at the 5 % level, indicating that the central city has a significant impact on the regional coordinated development of Guangdong, Hong Kong and Macao. In the overall model, the explanatory power of the Beijing-Tianjin-Hebei region is stronger, while the explanatory power of the Yangtze River Delta and Guangdong, Hong Kong and Macao is lower. These results show the heterogeneity of different regions in terms of coordinated development, indicating that policies and development strategies need to be adjusted according to the characteristics of specific regions.

(3) Transmission mechanism analysis

1) Innovation analysis

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 lv_{it} + \beta_3 R_{it} + \mu_i + \varepsilon_{it}$$

$$K_{it} = \vartheta_0 + \vartheta_1 Y_{it} + \vartheta_2 lv_{it} + \vartheta_3 R_{it} + \mu_i + \varepsilon_{it}$$

$$Y_{it} = \alpha_0 + \alpha_1 X_{it} + \alpha_2 K_{it} + \alpha_3 lv_{it} + \alpha_4 R_{it} + \mu_i + \varepsilon_{it}$$

Among them, *i* represents the region, *t* represents the year, μ_i is the unobservable regional effect, ε_{it} is the random disturbance term, Y_{it} represents the regional coordinated development index, X_{it} is the driving force of the central city, Iv_{it} is the proportion of fiscal expenditure to GDP and the level of infrastructure investment, R_{it} is the fiscal expenditure rate, and K is the scientific and technological innovation.

In this paper, stata 15.0 is used to regress the panel data from 2011 to 2020, and the results are shown in the table.

	(1)	(2)	(3)

	Y	K	Y
X	0.0548***	0.545***	0.0645***
	(6.38)	(4.54)	(6.17)
K			-0.0179**
			(-2.13)
lv	0.239	5.401	0.336
	(0.67)	(1.52)	(1.03)
R	0.288***	2.261***	0.329***
	(4.46)	(2.85)	(4.83)
_cons	-0.106	8.462***	0.0448
	(-1.09)	(7.16)	(0.39)
N	180	180	180
R2	0.273	0.691	0.278

statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

The results show that : (1) At the significance level of 1 %, urban driving has a positive impact on regional coordinated development. (2) At the significance level of 1 %, city driving has a positive impact on regional coordinated development, which means that it promotes innovation. (3) At a significant level of 5 %, innovation has a negative impact on urban driving capacity. The mediating effect of innovation has been confirmed, that is, urban driving capacity affects regional coordinated development through innovative channels.

The results show that the rapid development of the central city not only improves its own economic level, but also promotes the coordinated development of the surrounding areas through industrial diffusion and technology dissemination. This result supports the theoretical basis of the central city as the engine of regional development, and emphasizes the importance of urban economic development in improving the overall level of regional development. At the same time, central cities usually have strong innovation ability and resource advantages, and promote scientific and technological innovation by attracting high-tech enterprises, R & D institutions and high-quality talents. Innovation not only enhances the economic competitiveness of the city, but also provides technical support and market opportunities for the surrounding areas, thus promoting the coordinated development of the whole region. Although, at the 5 % significance level, innovation has a negative impact on the city 's driving ability. This result shows that although innovation has promoted regional coordinated development to a certain extent, over-reliance on innovation may lead to the weakening of urban driving capacity. Possible reasons include that excessive pursuit of technological innovation may lead to excessive concentration of resources and investment imbalances, thus affecting the radiation capacity of the central city to the surrounding areas.The mediating effect of innovation has been confirmed, that is, the driving ability of central cities affects regional coordinated development through innovative channels. This finding highlights the important role of scientific and technological innovation as a bridge between the coordinated development of central cities and regions. By promoting innovation, central cities have improved their economic capacity and technological level, thus further promoting the coordinated development of the region. This mediating effect shows that policy makers should pay attention to the improvement of innovation ability when considering the development of central cities, so as to achieve more extensive regional coordinated development.

2) Analysis on human capital

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 lv_{it} + \beta_3 R_{it} + \mu_i + \varepsilon_{it}$$

$$Ca_{it} = \vartheta_0 + \vartheta_1 Y_{it} + \vartheta_2 lv_{it} + \vartheta_3 R_{it} + \mu_i + \varepsilon_{it}$$

$$Y_{it} = \alpha_0 + \alpha_1 X_{it} + \alpha_2 Ca_{it} + \alpha_3 lv_{it} + \alpha_4 R_{it} + \mu_i + \varepsilon_{it}$$

Among them *i* represents the region, *t* represents the year, μ_i is the unobservable regional effect, ε_{it} is the random disturbance term, Y_{it} represents the regional coordinated development index, X_{it} is the driving force of the central city, Iv_{it} is the proportion of fiscal expenditure to GDP and the level of infrastructure investment, R_{it} is the fiscal expenditure rate, and Ca is human capital.

In this paper, stata 15.0 is used to regress the panel data from 2011 to 2020, and the results are shown in the table.

	(1)	(2)	(3)
	Y	Ca	Y
X	0.0548***	319.0***	0.0453***
	(6.38)	(5.10)	(5.74)
Ca			0.0000299**
			(2.42)
Iv	0.239	1475.8	0.195
	(0.67)	(1.49)	(0.53)
R	0.288***	-301.9	0.297***
	(4.46)	(-0.98)	(4.68)
_cons	-0.106	8.462***	0.0448
	(-1.09)	(7.16)	(0.39)
N	180	180	180
R2	0.273	0.780	0.276

t statisatics in paraentheses

* p<0.05, **p<0.01,***p<0.001

The results show that : (1) At the significance level of 1%, urban driving capacity has a positive impact on regional coordinated development. (2) At the significance level of 1%, the driving ability has a positive impact on the level of human capital, which means that it contributes to the level of regional coordination. (3) At the significant level of 1%, urban driving capacity and human capital have a positive impact on regional coordination. The test of human capital intermediary effect is significant, which shows that urban driving affects regional coordinated development through human communication channels.

The results show that the development of central cities and economic activities can effectively promote the coordinated development of surrounding areas. By leading economic growth, technological innovation and industrial transformation, central cities can drive the surrounding areas in terms of resource allocation, market access and development opportunities, thus narrowing the development differences between regions and improving the coordinated development level of the whole region. At the significance level of 1 %, the driving ability has a positive impact on the level of human capital, which means that the urban driving ability helps to improve the level of human capital in the region. Central cities are usually able to attract high-quality talents and educational resources, and enhance the level of human capital in the region through vocational training, skill improvement and higher education. This improvement not only helps to improve labor productivity, but also promotes innovation ability and lays a human foundation for regional coordinated development.In addition, at the 1 % significance level, urban driving capacity and human capital have a positive impact on regional coordination. This result emphasizes the mutual promotion relationship between urban driving ability and human capital. Cities attract and cultivate human capital by enhancing their driving ability. In turn, the improvement of human capital further enhances the driving ability of cities, thus forming a benign cycle. This cycle not only promotes the development of the city itself, but also promotes the coordinated development of the region. Therefore, the test of human capital intermediary effect is significant, which shows that urban driving ability affects regional coordinated development through human communication channels, and confirms the important bridge role of human capital between urban driving ability and regional coordinated development. The driving ability of the central city improves the quality of human resources and innovation ability of the surrounding areas by improving the level of human capital, thus affecting the coordinated development of the region. This mediating effect emphasizes the importance of enhancing human capital in policy formulation to achieve more effective regional coordinated development.

5. Research Conclusions and Suggestions

(1) Research conclusion

This paper discusses the role and mechanism of central cities in driving the coordinated development of urban agglomerations. The imbalance of regional development is a common problem in the modernization of all countries. Urban agglomerations attract capital, technology and talents through economic agglomeration effects, form economic growth poles, and drive the economic development of surrounding areas through diffusion effects. As a regional economic growth pole, the central city has the function of agglomeration and radiation, and is the engine to promote the coordinated development of the region.

Based on the theory of regional division of labor, Marxist urban spatial development theory and spatial balanced development theory, this paper analyzes the various influencing mechanisms of central cities on regional coordinated development, including industrial agglomeration and infrastructure construction, human capital attraction and training, and technology spillover. Through empirical analysis, the study selected the three major urban agglomerations of Beijing-Tianjin-Hebei, Yangtze River Delta and Guangdong-Hong Kong-Macao, and used the data from 2011 to 2022 to construct the central city leading role index and regional coordinated development index. The fixed effect model and the intermediary effect model were used for analysis, and it was found that the central city had a significant positive impact on regional coordinated development.

(2) Recommendations

Based on the previous research, combined with the actual situation of the integration of digital and real economy in China, in order to give full play to the role of financial technology and promote the integration of digital economy and real economy, the following suggestions are put forward.

First of all, we should optimize the industrial layout and strengthen infrastructure construction. Secondly, we should pay attention to the introduction and cultivation of human capital and promote scientific and technological innovation.

References

[1] Myrdal,G.Economic Theory and Under,developed Regions,Duckworth,1957.

[2] Wei Houkai.Deeply grasp the essential connotation of urban-rural integration development [J].China 's rural economy,2020,(06):5-8.

[3] Liu Zhiyan,Cheng Hao,Feng Haishan.Research on the effectiveness and mechanism of national central cities driving the development of urban agglomerations [J].Price theory and practice,2023,(05):19-25+117.

[4] Mao Yanhua,Xin Chaohui,Rong Jianxin.Spatial structure and agglomeration diffusion characteristics of central cities in Guangdong-Hong Kong-Macao Greater Bay Area [J].Journal of South China Normal University (Social Science Edition), 2021,(06):26-37+205.

[5] Wang Jun,Yang Benjian.Research on the mechanism and realization path of the radiation driving effect of central cities [J]. Journal of Sun Yat-sen University (Social Science Edition),2022,62(01):161-167.