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Shifting Centers of Gravity: Analyzing the Changing Patterns of Population and Economy in China

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Abstract

This study examined: 1) the shifting patterns of population, economy, and center of gravity in each industry using the regional center of gravity model, and 2) the socioeconomic factors influencing the economy and population in China using the geographic detector model. Several major findings included the following: First, the population and economic gravity center have shifted generally to the southwest. The centroid of gravity model can capture the changes in regional disparities from a dynamic perspective and visualize the changes over time. Second, while both the primary and secondary sectors have transferred their centers of gravity to the northwest, the tertiary sector's center of gravity has shifted to the southwest. Third, educational resources, financial distribution, and the tertiary sector have a substantial influence on economic growth, whereas the impact of financial distribution, educational resources, and the secondary sector on population density growth is relatively significant. This study contributes to offering valuable insights into the changing patterns of population, economy, and industry in China, as well.

Keywords

Gravity Centers, Regional Uneven Development, North-South Differences, Geographic Detector Model

1. Introduction

China has shown a significant regional uneven development; specifically, the regional differences in eastern, middle, and western China have garnered great attention, but the northern and southern regions have received less and less. More importantly, the gap between northern and southern China has become an

emerging issue affecting the sustainable development of Chinese regions. Thus, understanding the patterns and drivers of these changes is important for policymakers, businesses, and researchers seeking to navigate China's evolving economic landscape. In this regard, this paper attempts to: 1) identify the development gaps between the northern and the southern regions from the dynamic perspective, and 2) examine the factors influencing demographic and economic development. We explored the changing patterns of population, economy, and center of gravity of each industry in China using the centroid of gravity and geographic detector models. We collected and used data sets on population, GDP, and industrial output at the provincial level between 1978 and 2021. We believe that our study provides insights into the changing patterns of population, economy, and industry in China over the past few decades, as well as the factors that influenced these changes. By shedding light on these trends and drivers, we hope to contribute to a better understanding of China's economic development and inform future research and policy decisions.

2. Background

2.1. Urban Growth Pattern in China

In recent decades, China has undergone significant changes in terms of economy, social structure and infrastructure, achieving many historical milestones (Chen et al., 2016). Between 1986 and 1990, a planned economy was transformed into a market-dominated system, and during this period, the "era of reform and opening up", the size and structure of the population in most provinces led to changes in spatial distribution patterns. At that time, China officially adopted the policy of three major economic zones (coastal, central and western regions) (Fan, 1997), to overcome and reform the uneven pace of economic growth among regions (Xu & Wang, 1997). Coastal regions have experienced faster economic growth than inland regions. Several factors, such as poor economic fundamentals, uneven and low-quality education condition, insufficient capital investment, closed economic policies, and differences in natural conditions among the inland provinces, have been identified as the main reasons for these imbalances (Li, 1995). In this process, the discrepancy between the demand for a better quality of life and the uncoordinated development of different regions has emerged as a major social issue in China (Chen et al., 2019). In response, China has set the strategic goal of sustainable development, marking a new stage of interregional development.

2.2. Empirical Studies

There has been a substantial corpus of past research with empirical findings. According to Xu & Yue (2001), the demographic center of gravity gradually shifted to the southwest, whereas the economic center of gravity shifted to the southeast. Through a study of the economic center of gravity, Ye (2012) discov-

ered that the North's lagging economic development is also a significant element in the transfer of the economic center of gravity to the South. In a study of population and economic centers of gravity, Liu et al. (2019) discovered that the economic center of gravity travels quicker than the population center of gravity and that the space between the two is shrinking. Li et al. (2017) investigated the spatial and temporal evolution trajectories of economic, industrial, and population centers of gravity and concluded that regional development differences in the east-west direction of economic centers of gravity tend to narrow, whereas differences in the north-south direction may expand further. In general, the center of gravity of major industry shifts to the southwest. The secondary industry center of gravity and the economic center of gravity have comparable spatial and temporal trends. The population, economic center of gravity, and tertiary industry center of gravity are all moving in the same direction. Chen (2022) researched China's regional economic and industrial spatial layout and determined that the country's economic center of gravity is shifting south and west. And the primary industry's link to the economy is progressively fading, while the secondary industry's connection to the economy is stronger, and the tertiary industry's relationship to the economy is gradually strengthening. Wang (2022) investigated economic and demographic trends, as well as spatial planning, and discovered an overall shift in the center of population and economic gravity to the southwest. Regional differences are stronger between northern and southern China than between eastern and western China.

In sum, numerous studies have investigated the spatial patterns and factors influencing the movement of China's population and economic center of gravity. According to the studies, the population and economic centers of gravity are continuing to shift to the southwest, and the distance between the population and economic centers of gravity is gradually shrinking. Secondary and tertiary industries are highly associated with population and economy, and the gap is gradually closing.

2.3. Methodological Approach

As a research method for regional development differences, the center of gravity or centroid can objectively and reflect regional development differences in time and space. The concept of centroid was first developed to analyze the massive population movements caused by the development of the western United States. Aboufadel (2006) proposed the use of a centroid approach to study population distribution and change in the United States. The method does not rely on a map projection. Grether et al. (2010; 2011) use centroids to examine the trajectory of the world's economic center of gravity, which is steadily shifting toward Asia. And improvements to the center of economic gravity are suggested. Therefore, this method is beneficial to study the direction and balance of national or regional development and to evaluate the impact of policies on regional development (Zhang et al., 2012).

In this context, the demographic and economic center of gravity has been a hot topic in regional development research. Its dynamic changes could reflect regional economic development trajectories and reveal the demographic-economic development laws and connections (Lin et al., 2014). According to Li (1983), the population center in China initially moved back and forth between the east and the west, but the main center remained in the east and south of China. Later, Lian (2007) studied the spatial evolution trajectory of the center of gravity of employment, and interpreted that the main cause of regional economic disparity in China was the serious imbalance in the distribution of production and employment between the eastern coastal regions and the central and western regions. Yang (2017) argued that the coherence of population and economy is stable in the eastern and central regions, and weak in the western region. Furthermore, in the urban dimension, Li & Luo (2017) concluded in their study of the Beijing-Tianjin-Hebei region that the center of gravity of the population deviates from the center of gravity of the economy to varying degrees. Huang et al. (2019) in the study of nighttime light data with population and economic gravity, showed that the correlation between economy and nighttime light intensity is higher than the correlation between population and nighttime light intensity.

2.4. Research Gaps

The above literature provides a good theoretical basis for studying spatial heterogeneity and regional development differences. Patterns of regional change can be inferred, and reasonable expectations of regional change can be made. However, there are still few studies on the development trends of industry, population, and the economy and few studies between the South and the North. Recently, the East-West gap has narrowed, but emerging issues have emerged for North-South regional disparities. Also, most studies have rarely analyzed the factors influencing demographic and economic development.

3. Research Design

3.1. Variable

Population serves as a critical foundation for economic development, and conversely, industry plays a vital role in driving economic growth. The interplay between population and industry is reciprocal, as the clustering of the industry often leads to the concentration of population. The spatial distribution of population and industry is an important economic phenomenon that affects each other. Whether the population and industry are properly matched and proportioned for development can significantly affect the cooperation and progress between regions (Guan et al., 2018). Population density and economic growth are important aspects of China's economic and social development, but the spatial patterns of both population growth and economic growth are influenced by a variety of social factors. Here, we try to analyze the factors affecting population density and economic growth to promote balanced regional development in the

south and north of China. Therefore, based on the literature review, we selected six indicators under three types to analyze their influence on population density and economic growth (Table 1).

The economic factors include fiscal revenue, the share of the secondary sector in GDP, and the share of the tertiary sector in GDP. Industrial structure refers to the ratio of primary, secondary, and tertiary sectors in the national economic structure of a country or region. The industrial structure plays an important role in improving economic efficiency. The contribution of the secondary and tertiary sectors to economic growth is significantly higher, which contributes to the continuous optimization of the economic structure (Zhou et al., 2023). The development of the market economy is the booster of economic efficiency, and the level of economic development directly determines the size of the fiscal scale, and local fiscal revenue can be used as an indicator to reflect the level of economic development (Yu et al., 2016). Social factors include the urbanization rate and the number of universities. The urbanization rate is the proportion of the urban population in the total population, and the urbanization process has been considered part of the economic development process (Shabu, 2010). Universities have a broad impact on the development and economic growth of cities. Universities form a bridge between different institutions, industries, and citizens. And by attracting investors and intellectual capital, they can support the development of communities and have the capacity to transform cities and the environment in a variety of ways (Ischinger & Puukka, 2009). Government decisions include fiscal expenditures that affect the distribution of limited resources among different levels of cities. The more these resources are invested, the greater the capacity of the region to accommodate population and economic development (Wu et al., 2018).

Table 1. Variable description (Sample size: 31).

Influencing categories	Methods and measured value	Indicators	Descriptive Statistics	
			Mean	Standard Deviation
Economic factors	Degree of market development	Fiscal revenue as a percentage of GDP	11	3
	Industrial structure	Share of secondary sector in GDP	43	7
		Share of tertiary sector in GDP	38	6
Social factors	Urbanization level	Urbanization rate	41	13
	Educational Resources	Number of Universities	50	24
Governmental decisions	Finance distribution	Fiscal expenditure as a percentage of GDP	27	18

3.2. Methodological Approach

3.2.1. The Centroid of Gravity

This study used the centroid of gravity model since it can capture the changes in regional disparities from a dynamic perspective, visualize the change over time, and provide insights into the regional uneven development (Klein, 2009). Using this method, we examined the differences in regional development and population movement trends in China through the analysis of the movement of the centers of gravity of population, economy, and industry at the provincial level. The latitude-longitude coordinates and movement distances of the gravity centers were also calculated to provide a visual comparison of their movement characteristics.

The basic formula for calculating the demographic or economic center of gravity is as follows (Shen et al., 2009).

$$X = \frac{\sum_{i=1}^{n} M_i X_i}{\sum_{i=1}^{n} M_i}, Y = \frac{\sum_{i=1}^{n} M_i Y_i}{\sum_{i=1}^{n} M_i} \tag{1}$$

Equation (1) is, X and Y represent the longitude and latitude of the demographic and economic gravity centers in the whole area respectively, X_i and Y_i represent the coordinates of the geographic gravity centers in the sub-region, i represents the i-th research unit, n represents the total number of research units, and M_i is the demographic or economic weight. When M_i is expressed as the population number of a sub-region, the population gravity coordinate center is obtained, and when M_i is expressed as the GDP of a sub-region, the economic gravity coordinate center is obtained (Liang et al., 2021).

The formula for the movement distance of the center of gravity center movement distance is formulated as follows.

$$D_{a\text{-}b} = C \times \sqrt{\left(Y_a - Y_b\right)^2 + \left(X_a - X_b\right)^2} \tag{2}$$

Equation (2) is, $D_{a\text{-}b}$ is the distance traveled between two different years. c is a constant and is the conversion rate between geographic and planar projection coordinates, 10 ≈ 111.111 km.

3.2.2. Geographic Detector Model

By studying the centroid of gravity model, can see the trajectory of the centroid of population, economy and industry. However, in order to further explore the reasons that influence the change of the center of gravity, a geographic detector model is used here. This study also employed the geographic detector model to analyze 1) spatial stratified heterogeneity, 2) the spatial distribution of the independent and dependent variables, and 3) the similarity between the independent and dependent variables. The model consists of 4 detector modules: factor, risk, ecology, and interaction. Among them, we applied detector modules suitable for this study, the factor detection module. The factor detection module is used to

detect the spatial divergence of the dependent variable and to detect the extent to which the independent variable can explain the spatial heterogeneity of the dependent variable, measured by the q-value.

Factor detection is used to detect the spatial divergence of the dependent variable and to detect the extent to which the independent variable can explain the spatial heterogeneity of the dependent variable, measured by the *q*-value. The factor detection formula is as follows (Li et al., 2019).

$$q_{p,g} = 1 - \frac{1}{A\sigma^2}\sum_{y=1}^{x} A_y \sigma_y^2 \tag{3}$$

Equation (3) is, $q_{p,g}$ are indicators of the degree of spatial heterogeneity. $y = 1, 2, 3, \ldots, x$ is the stratification of variables. A is the total sample size of the study. A_y is the sample size of the study neutron region. σ^2 is the variance of the dependent variable. σ_y^2 is the variance of the dependent variable in the sub-region.

Among them, the value of $q_{p,g}$ lies in [0, 1]. $q_{p,g}$ higher value of A indicates a higher influence of the dependent variable on the independent variable. $q_{p,g} = 0$ means that there is no relationship between the dependent and independent variables. $q_{p,g} = 1$ means that the dependent variable is completely determined by the independent variable.

3.3. Data

The study used the population and GDP data of 31 provinces (including 5 autonomous regions and 4 municipalities directly under the central government) in China after the reform and opening up in 1978 as the basic statistics. Considering the accuracy and stability of the data, the three regions of Macau, Taiwan, and Hong Kong, were excluded from this study. The geographical coordinates used in the centroid model are the latitude and longitude coordinates of the capital cities of each province, due to the large range of coordinates in each province. The demographic and economic data and the six factors used in the geographic detector model were obtained from the statistical yearbooks of the National Bureau of Statistics of China for each year.

4. Findings

4.1. Centroid of Gravity

4.1.1. Changing Trajectory of the Population Gravity Center

From 1978 to 2021, the gravity center of the population shows a shift to the southwest. Specifically, "first to the southwest, then to the northeast, then to the southeast, and finally to the southwest". The total distance moved is more than 54 km (**Figure 1**). In general, the movement of the population gravity center generally does not vary much from year to year. However, there is a clear overall trend that the population gravity center is shifting southward over a long period. Years in the third stage are generally tilted to the southeast. Differences in population distribution between the northern and southern regions persist.

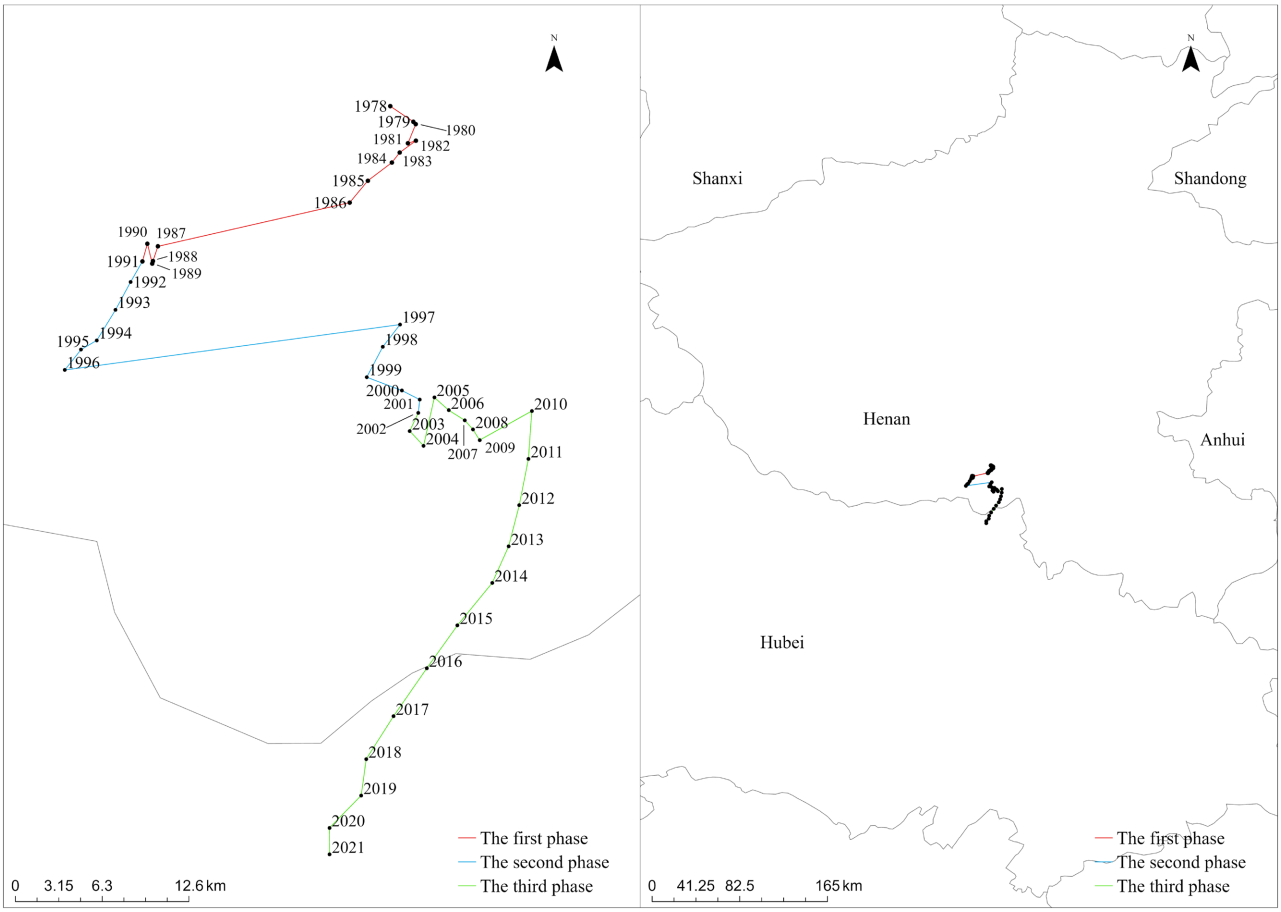

Figure 1. Trajectory of the center of gravity of the population from 1978 to 2021.

The first phase (1978-1991): During this period, the population center shifted to the southwest. The population center shifted a total of 24.38 km to the south and 2 km to the north, with a significant shift to the south. In 1988-1989, the population center briefly shifted to the southeast but soon returned to the northwest-southwest direction.

The second phase (1992-2002): The center of gravity of the population has shifted a total of 31.01 km to the south and 20.08 km to the north. In 1992, with the establishment of the socialist market economy, urban reform and development entered a rapid development stage, the rural labor force went out again, and the population center shifted 7.52 km to the southwest from 1992 to 1995. In 1997, the population center moved 20.8 km to the northeast. From 1999 to 2001, the population center shifted 3.63 km to the southeast.

The third phase (2003-2021): The population center shifted a total of 42.3 km to the south and 7.39 km to the north. 3.56 km and 3.83 km were shifted to the northeast from 2004 to 2005 and 2009 to 2010, respectively, and then the population center continued to shift to the southwest.

4.1.2. Trajectory of the Economic Center of Gravity

From 1978 to 2021, the centers of economic gravity show a shift to the south-

west. Specifically, "first to the southwest, then to the southeast, and finally to the southwest". The total distance moved is more than 222.85 km (Figure 2). The movement of the centers of economic gravity does not change much from year to year. Nor do they seem to span relatively large areas, as do the population centers. However, there is also a clear general tendency for centers of economic gravity to move southward over long periods.

The first phase (1978-1991): The economic center of gravity shifted a total of 117.52 km to the south and 20.03 km to the north. In 1984, China formulated a policy to reform the economic system, and the economic system entered a transition period dominated by the resource economy. From 1980 to 1981, China established four special economic zones in Shenzhen, Zhuhai, Xiamen, and Shantou. The accelerated economic development in the south also shifted the economic center of gravity 17.57 km to the southwest. In 1981, the North China Economic and Technical Cooperation Zone was established, which shifted the economic center of gravity 16.59 km to the northwest. In 1983, the Shanghai Economic Zone, the Northeast Economic Zone, and the Five Southwest Provinces Economic Cooperation Zone were established. From 1985 to 1987, the economic center of gravity briefly shifted 10.21 km to the southeast. Then it returned to the southwest direction.

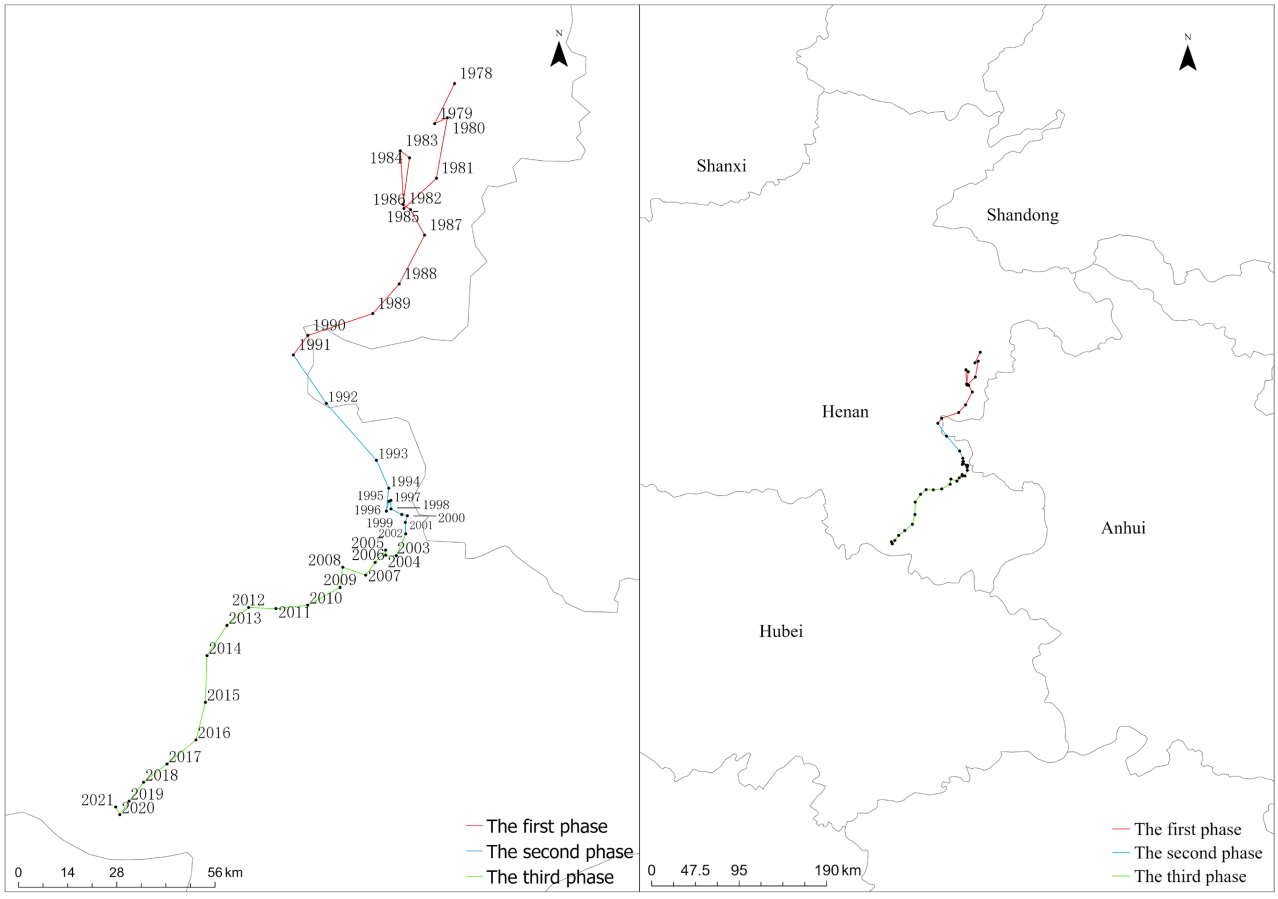

Figure 2. The moving trajectory of economic gravity center from 1978 to 2021.

The second phase (1992-2002): The economic center has shifted a total of 63.56 km to the south and 3.42 km to the north. In 1992, with the publication of Deng Xiaoping's Southern Speech, China's economic system was defined as a socialist market economy. From 1992 to 1993, with the development of the Yangtze River Delta city cluster, the economic center of gravity shifted 20.28 km to the southeast. 1994, Guangdong proposed the establishment of the Pearl River Delta city cluster, and from 1994 to 1995, the center of economic gravity shifted 6.62 km to the southwest. In 1997, due to the Asian financial crisis, the economic center of gravity shifted 0.54 km to the northeast. From 1998 to 2000, the economic center of gravity shifted 4.4 km to the southeast, and in 2001, China joined the World Trade Organization, which brought great development to the southeast. From 2001 to 2002, the economic center of gravity shifted 3.29 km to the southeast.

The third phase (2003-2021): The economic center shifted a total of 108.3 km to the south and 19.02 km to the north. The economic center shifted to the southwest during this period. After 2003, the Chinese government proposed development strategies such as the development of the western region, the comprehensive revitalization of the northeast region, and the rise of the central region to coordinate the common development of all regions and significant achievements were made in regional development. From 2003 to 2004, the economic center first shifted 2.58 km to the west, then 1.48 km to the northeast in 2005. In 2007, China proposed a development plan for the western region, and the economic center had already shifted 5.96 km to the northwest. In 2008, the outbreak of the international financial crisis affected the southeast coastal region, and the economic center of gravity shifted 5.85 km to the southwest. From 2013 to 2020, the center of gravity will continue to shift 60.16 km to the southwest. In 2021, the centroid shifts 2.4 km to the northwest.

4.1.3. The Shift in the Gravity Center of the Primary Industry

From 1978 to 2021, the center of the primary industry shows a shift to the north. Specifically, it moved to the northwest, then to the southwest, and finally to the northwest. In total, the center of the primary industry shifted 311.96 km to the south and 289.73 km to the north (**Figure 3**).

From 1978 to 2002, there was no pattern in the trajectory of the shift of the center of gravity of the primary sector. 2003 saw the introduction of China's "Three Rural Policies". Tax cuts and reforms in agriculture were stepped up and farmers were subsidized. As a result, the country's core grain-producing regions of Henan and the fertile black soil of the northeast were greatly developed, and the center of gravity of the primary industry shifted 38.76 km north from 2003 to 2012. In 2013, China proposed to accelerate the development of agricultural mechanization and vigorously increase the investment in rice mechanization and mountain mechanization. By 2018, the center of gravity had shifted 77.44 km south. In 2018, China proposed a rural revitalization strategy, and the center of gravity shifted another 25.22 km northward.

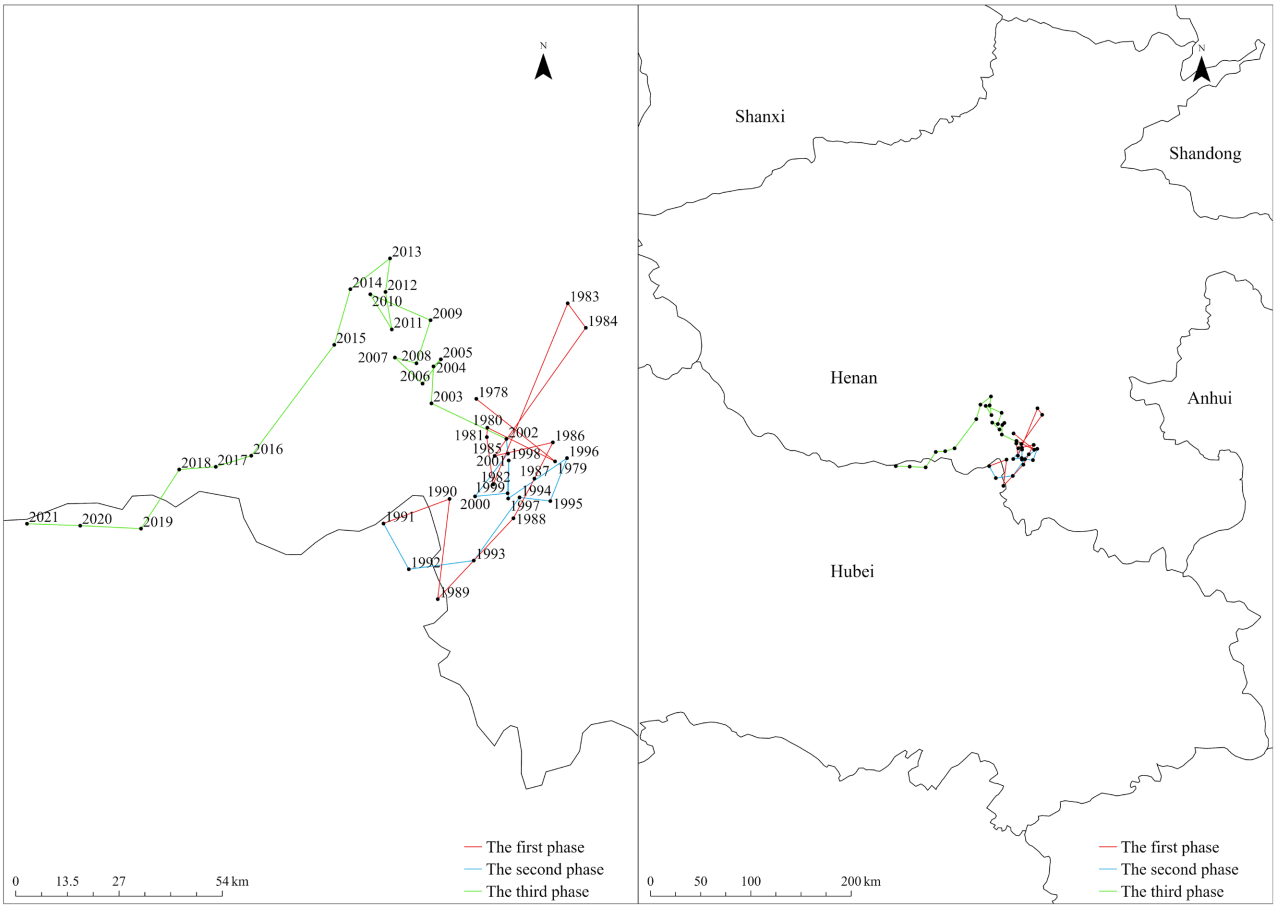

Figure 3. The moving trajectory of primary industry gravity center from 1978 to 2021.

4.1.4. The Shift in the Gravity Center of the Secondary Industry

The total distance of the movement was more than 427.55 km. In total, it shifted 400.35 km to the south and 204.32 km to the north (**Figure 4**).

From 1980 to 1982, the center of gravity of the secondary industry shifted 21.21 km to the southeast. In 1983, the Chinese government improved the infrastructure in the northwest and southwest, so the center of gravity shifted 12.88 km to the northwest from 1983 to 1984. With the Chinese government's proposal in 1985 to establish coastal economic development zones in the Yangtze and Pearl River deltas, the center of gravity of the secondary industry shifted 15.38 km to the southeast by 1986. With the development and promotion of "China's Western Development Strategy" in 2003, the center of gravity shifted 101.05 km to the northwest from 2003 to 2005. From 2006 to 2020, the center of gravity shifted back to the southwest due to the natural resources, geographical environment and industrial advantages of the southwest region.

4.1.5. The Shift in the Gravity Center of the Tertiary Industry

The total distance of the movement was more than 159.04 km. In total, it moved 254.41 km to the south and 63.44 km to the north. The trajectory of the tertiary sector center of gravity is similar to the trajectory of the population and

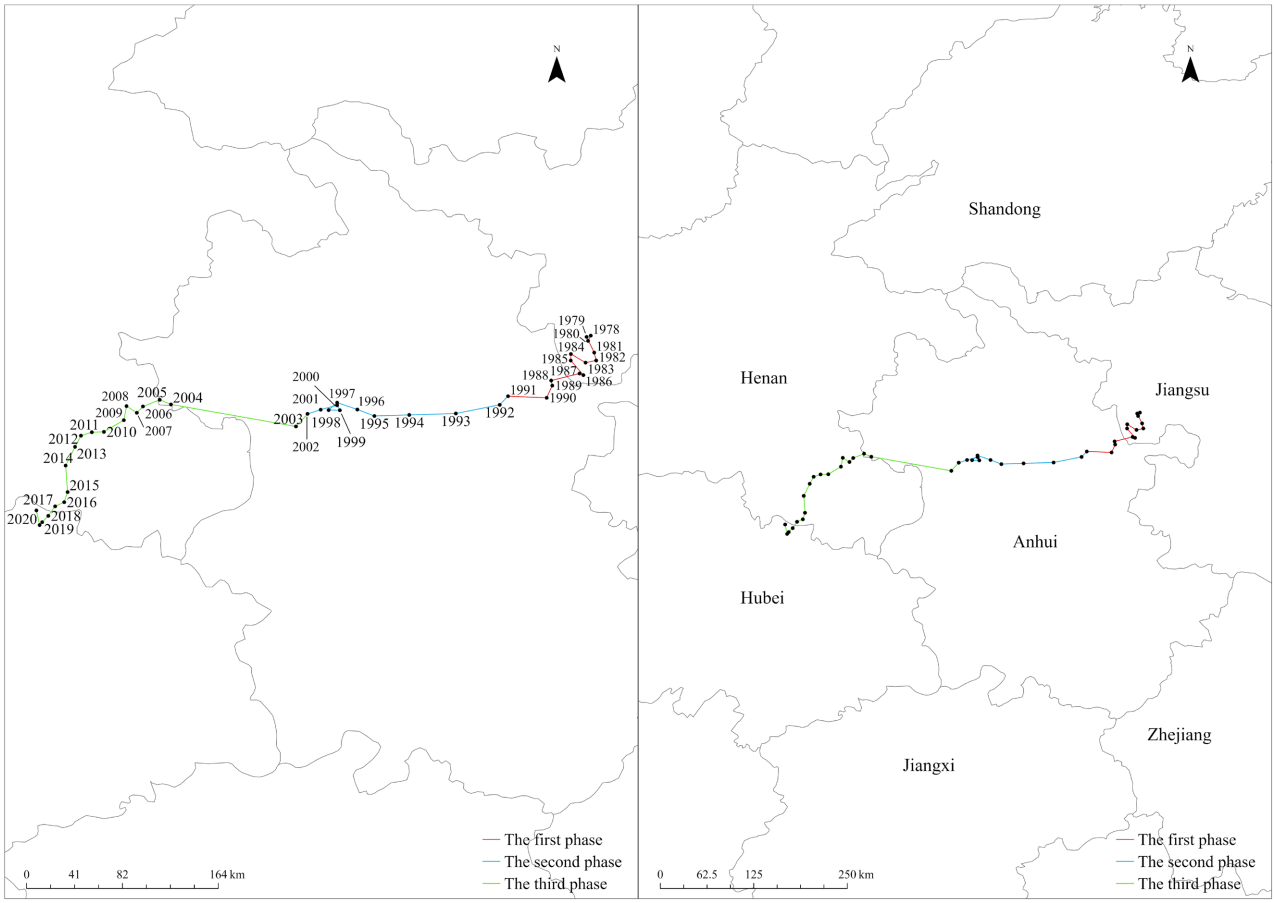

Figure 4. The moving trajectory of secondary industry center of gravity from 1978 to 2021.

economic center of gravity. In general, the center of gravity of the tertiary sector shows a tendency to move first to the southeast and then to the southwest, with a brief move to the northeast (**Figure 5**).

From 1980 to 1981, the center of gravity of the tertiary sector shifted 13.09 km to the southeast. From 1982 to 1983, the center of gravity of the tertiary sector briefly shifted 16.45 km to the northeast. However, with the establishment of the socialist market economy system and the rapid development of the south in 1992, the center of gravity of the tertiary sector began to shift significantly to the southeast, shifting 29.72 km. The impact of the Asian financial crisis on the South in 1997 caused a brief shift of 6. In 2010, China proposed to lead the overall economic and social development with the scientific concept of development, and with the coordinated development of inter-regional from 2010 to 2012, the center of gravity of the tertiary sector also shifted 13.84 km to the northwest. Since 2013, the tertiary industry center of gravity has continued to shift southward.

4.1.6. Linkage Analysis of Population, Economic and Industrial Focus

Spatial demonstration of the trajectory of the population center of gravity, economic center of gravity, and industrial center of gravity from 1978-2021 using

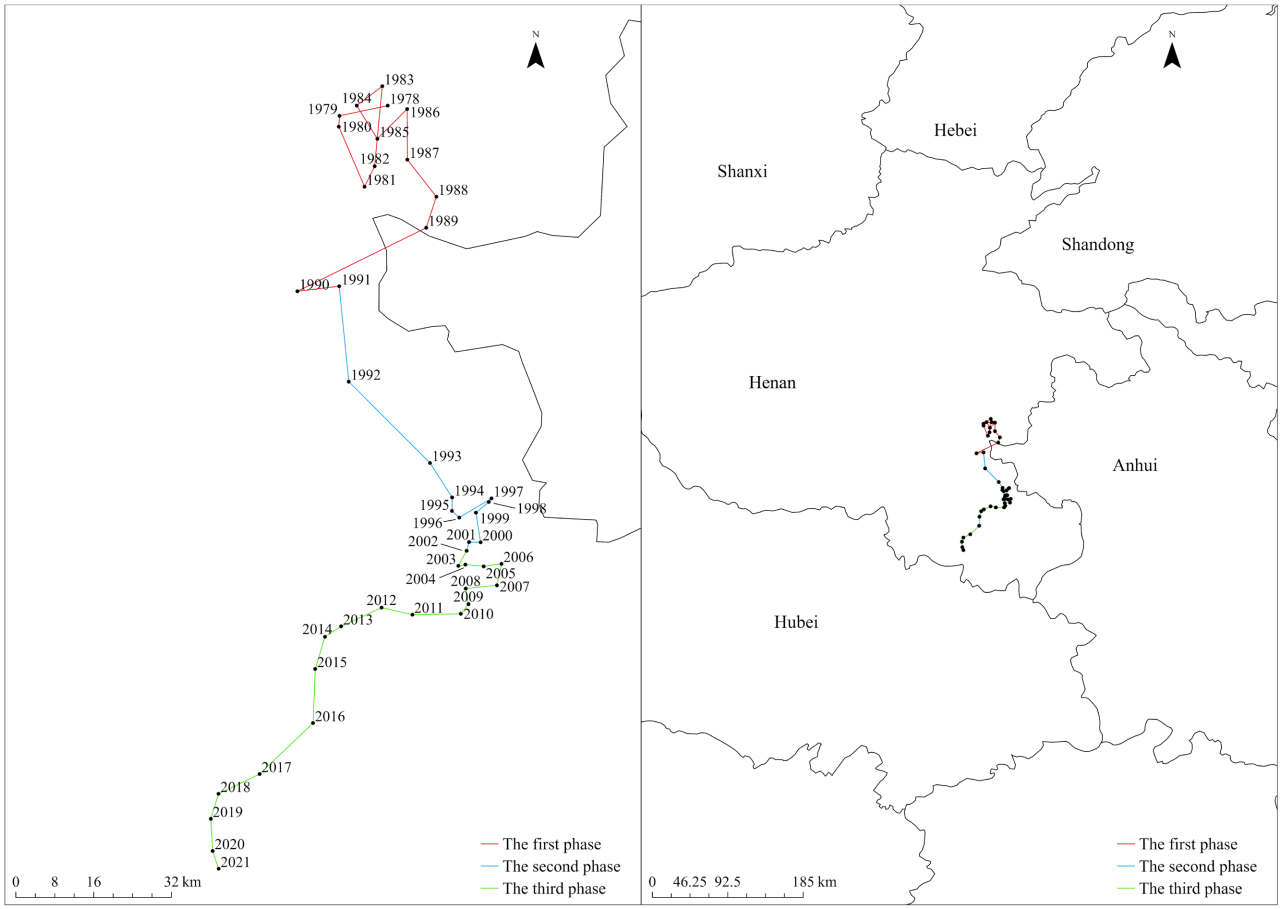

Figure 5. The moving trajectory of tertiary industry gravity center from 1978 to 2021.

ArcGIS software. Then the distance between each center of gravity was calculated. The distance between China's population center of gravity and its economic center of gravity has decreased from 205.24 km in 1978 to 90.78 km in 2021, which is a significant decrease. This indicates that both centroids of gravity are moving in the same direction. Although the trajectories of movement do not overlap, the trend is the same for both. The distance between the centroid of China's population and the centroid of the primary sector increases from 34.78 km in 1978 to 63.22 km in 2021 (**Table 2**). The distance to the gravity center of the secondary industry shrinks from 473.3 km in 1978 to 90.25 km in 2021, indicating the same trend of movement between the two. The distance to the center of gravity of the tertiary sector shrinks from 152.11 km in 1978 to 112.99 km in 2021. The distance between the center of gravity of China's economy and the center of gravity of the primary sector increases from 185.38 km in 1978 to 159.84 km in 2021. The distance to the gravity center of the secondary industry shrinks from 310.25 km in 1978 to 19.65 km in 2021, indicating the same trend of movement between the two. The distance to the gravity center of the tertiary sector shrinks from 57.52 km in 1978 to 18.97 km in 2021. It can be seen that the primary sector has little impact on the center of population and economic gravity.

Table 2. Values of factors affecting Population density and economic growth from 1978 to 2021.

Indicators of Macro-Level	Population density			GDP growth		
	p-value	*q*-value	Rank	*p*-value	*q*-value	Rank
Finance distribution	0.000	0.9247***	1	0.000	0.9140***	2
Market development	0.000	0.1893***	6	0.000	0.3672***	6
Educational resources	0.000	0.8901***	2	0.000	0.9867***	1
Urbanization rate	0.000	0.5425***	5	0.000	0.5991***	5
Tertiary industry	0.000	0.7164***	4	0.000	0.8267***	3
Secondary industry	0.000	0.7490***	3	0.000	0.6367**	4

*Significant at $p < 0.10$; **Significant at $p < 0.05$; ***Significant at $p < 0.01$.

The distance between the secondary sector and the population and economic centers of gravity has been significantly reduced, indicating significant progress in China's coordinated regional development strategy. The secondary sector has been used to reactivate the economic strength of the northern regions, thus attracting a large influx of population. However, as both the population and economic centers of gravity are shifting to the south, this indicates that the secondary sector is still better in the south than in the north. The gap with the tertiary sector is also narrowing and moving in a similar direction, suggesting that the tertiary sector remains the basis for population size and economic development.

4.2. Geographic Detector Model

Factor Detection Model

In this subsection, the geographic detection model is used to quantitatively analyze the factors that influence population density and economic growth. This model is based on the principles outlined in Equation (3) and uses the calculated values to determine the influence of various factors on the demographic and economic outcomes under investigation (Table 3). The *p*-values are all less than 0.01, indicating that the factors are significant for population density and economic growth.

The ranking of factors affecting population density is: financial distribution > educational resources > secondary industry > tertiary industry > urbanization rate > market development. Financial distribution as the basis of development can greatly influence population density with an impact coefficient q of 0.9247. This is because financial distribution can attract population movement to a certain extent. Fiscal expenditure can effectively support the development of transportation, agriculture, industry, infrastructure and tertiary industry in the region, which can greatly enhance its own strength. At the same time, fiscal distribution on education, medical care, health and other aspects of people's livelihood will also bring about an overall improvement in the quality of life in the

Table 3. Population center of gravity, economic center of gravity, and distance from each industrial gravity center.

Year/Center	1978			2021		
	primary industry	secondary industry	tertiary industry	primary industry	secondary industry	tertiary industry
Population	34.78 km	473.3 km	152.11 km	63.22 km	90.25 km	112.99 km
Economic	185.38 km	310.25 km	57.52 km	159.84 km	19.65 km	18.97 km

place of residence and migration, which also becomes an important factor for population mobility. The coefficient of influence of educational resources on population density is 0.8901. Higher education is an important determinant of human capital accumulation, and abundant higher education resources can promote the development of human resources, the quality of labor force, and thus greatly improve the overall level of the region. And the development of higher education also affects the population mobility of cities. And the better educated people are more willing to move to the well-developed areas, thus accelerating the population gathering. And the quality of educational resources is one of the most important factors in the transition from rural to urban population. The coefficient of influence of secondary industry on population density is 0.7490. With urbanization comes the need for more infrastructure development and more jobs to accommodate migrant workers. And with China's policy support and financial assistance to the northern regions in recent years, industrial areas have been revitalized, attracting a large number of migrant workers to return. The influence coefficient of tertiary industry on population density is 0.7164. The development of tertiary industry and its high wages have become an important factor in attracting mobile population. The higher the proportion of tertiary industry, the better the degree of industrial structure optimization, and the more reasonable the industrial structure, the more it can promote the increase of population urbanization. However, with the development of technology and the adjustment of industrial structure, new technology industries such as technology manufacturing have started to develop, but traditional industries still dominate in the north and cannot create a great attraction for the population. The coefficient of influence of urbanization rate on population density is 0.5425. This indicates that the urbanization process is inefficient and blind rapid urbanization should be avoided. For urbanization, it should be coordinated from many aspects and a more comprehensive urbanization program is needed. Market development can also reflect changes in population density, structure, and distribution with an impact coefficient q of 0.1893. It shows that population concentration must be ensured by stable market development, and fluctuations in market development should be avoided.

The ranking of factors influencing the size of the economy is: educational resources > financial distribution > tertiary industry > secondary industry > urba-

nization rate > market development. The coefficient of influence of higher education resources on economic growth is 0.9867. These universities are key to the development of the regional knowledge economy, and the concentration of various resources in them can have a positive impact on human capital, regional economy and urbanization. This not only contributes to the development of the regional economy and the upgrading of its industries, but also to the diversification and upgrading of the urban area, its overall strength, and its level of innovation. The small economic circle formed by universities can drive the development of the surrounding area and contribute to the improvement of the high-tech industry through the influx of highly educated people. China's recent plans to introduce talent to various provinces also illustrate the increasing role of talent resources in regional development, and the number of universities is directly related to the quantity and quality of talent. Financial distribution finances social development and also affects economic growth with an impact coefficient of 0.9140. Investment in education has the potential to improve the quality and competence of the workforce, giving individuals access to a wider range of employment opportunities. Technical training can further increase worker productivity. Spending on health and sports can improve the physical well-being of workers and reduce the impact of sickness absence. In addition, spending on revitalizing the old industrial base in the northeast, the Belt and Road Initiative, and rural development can promote balanced regional growth and drive economic expansion. With the continuous optimization and upgrading of the industrial structure, the proportion of the tertiary industry in the national economy has been increasing, playing an increasingly large role and having a great impact on economic growth, with an impact coefficient of 0.8267. However, the tertiary industry should accelerate the transition from the traditional tertiary industry to the modern tertiary industry. The northern regions rich in energy resources still need the pull of the secondary industry for economic growth, with an impact coefficient of 0.6367. The secondary industry, the core of the rapid economic development, has also pulled the economic development of the eastern and western regions of China. The rapid industrial transformation and development of the southeast coastal region has also led the northern region to take over part of the secondary industry. Urbanization has the lowest impact on economic growth with an impact coefficient of 0.5991. This indicates that the urbanization process is costly and inefficient. Blind rapid urbanization should be avoided. Fiscal revenue plays a crucial role in providing resources for government expenditure and enabling the redistribution of resources. Taxation is the main source of fiscal revenue, and by effectively managing tax policies and providing supporting measures, the government can promote structural transformation and upgrading of the industrial sector. For example, offering tax incentives for entrepreneurship and providing financial and technical support can spur the shift of focus from primary and secondary industries to tertiary indus-

tries. And market development is also related to the direction of government development. The largest impact on economic growth is observed with an impact coefficient of 0.3672. The higher impact coefficient of fiscal revenue as a reflection of the level of market development than fiscal expenditure also suggests that reducing government intervention and opening up the freedom of the market economy can better increase economic growth.

In conclusion, the three variables that have the greatest impact on the population are financial distribution > educational resources > secondary industry. The three factors that have the greatest impact on the economy are educational resources > financial distribution > tertiary industry.

5. Policy Implications

The research concludes with three suggestions for how the disparity in economic development between North and South China might be reduced. To begin, there should be an effort made to changes that are both deep and comprehensive to reduce the inefficiencies of the government and raise the openness of the market. This would be done to improve the investment environment in the north. To achieve this goal, constraints on market access must be loosened, the system of market monitoring must be improved, and further steps must be taken to create a level playing field for the growth of private businesses to increase employment. In addition, there should be efforts made to increase the efficiency of the government so that it can better serve the requirements of a market economy.

The second step is to expediate the process of opening up the northern area to the rest of the globe and to increase the degree to which the region is already accessible. Coastal regions, such as Tianjin and Shandong, should take advantage of the advantages afforded to them by their geographic locations, make use of the autonomy afforded to them in free trade pilot zones, and construct free trade ports that have unique characteristics. Border provinces, including Xinjiang and Inner Mongolia, should expand their economic cooperation with adjacent countries and take advantage of their geopolitical advantages to boost growth. This is particularly important in Xinjiang. In the meantime, the inland provinces should capitalize on the growth prospects presented by the national development policy and "The Belt and Road" by relying on the convenient transportation conditions that already exist in their areas.

Third, the northern region had to hurry up and complete its transition into the industrial sector. It is important that efforts be made to improve the overall innovative capability of the region, and that reforms be customized to the specific characteristics and requirements of the evolving industrial structure in the northern region. This involves making use of the region's significant resources of high-level expertise and enhancing policies to recruit and keep high-tech people. The formation of brand-new industrial clusters is founded on significant amounts of scientific and technological advancement.

6. Conclusion

The purpose of this article was to: 1) identify the development gaps between the northern and the southern regions from the perspective of dynamic analysis, and 2) investigate the factors that influence the demographic and economic development of the country. By utilizing the geographic detector model in conjunction with the centroid of the gravity model, we were able to investigate the shifting demographics, economies, and centers of gravity of various industries in China. Based on the findings of this study, it can be concluded that China's economy and population have undergone significant changes over the past four decades, with spatial patterns playing a crucial role in shaping these changes. The population and economic centers of gravity have shifted towards the southwest, and the center of gravity of the primary industry has shifted towards the northwest. The center of gravity of the secondary sector shifted briefly to the northwest and then to the southwest. The center of gravity of the tertiary sector shifted to the south. Additionally, several socio-economic factors, including educational resources, financial distribution, tertiary industry, secondary industry, urbanization rate, and market development, have been identified as impacting China's economic growth. This study provides valuable insights into the dynamics of China's economy and population from a spatial perspective and highlights the importance of considering spatial patterns in economic analysis and policymaking. As China continues to undergo rapid development and transformation, it will be essential to continue monitoring and analyzing these patterns to inform effective policy decisions and promote long-term economic growth and sustainability.

Nonetheless, there are still many unanswered questions and areas for future research. For example, it would be valuable to explore the reasons behind these shifts in greater detail, as well as the potential implications for various stakeholders. Additionally, further research is needed to deepen our understanding of the relationship between spatial patterns and economic growth and to explore the effectiveness of regional policies in promoting more inclusive and sustainable development. Furthermore, this study did not explore the role of regional policy in shaping the regional uneven development. Also, there is a need for more research on the spatial dynamics of China's transition to a knowledge-based economy. This includes exploring the spatial distribution of research and development (R & D) activities, high-tech industries, and human capital, as well as how these factors interact with spatial patterns of economic growth. Additionally, there is a need for more research on the potential implications of the population and economic center of gravity shifts on different stakeholders, including government policies, local communities, and private sector businesses. Finally, further research is required to explore the effectiveness of different policies in promoting inclusive and sustainable economic growth and development across different regions and industries in China.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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