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Article

What has caused regional (relative) poverty in China? A multi-dimensional and multi-factor analysis of 295 Chinese cities

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Abstract: Despite ongoing economic development around the world, poverty is becoming an increasingly important problem. Although absolute poverty still appears in some countries, relative poverty (the gap between the rich and the poor) has become the focus of attention. To learn what factors affect regional economic development, and therefore affect relative poverty, we selected 295 Chinese cities and analyzed their economic development problems using spatial econometric models (ordinary least-squares, spatial lag, and spatial error models), and city classification criteria (region and size). We found that optimization of the trade structure, improvement of medical resources, and development of fiscal decentralization and a market economy promoted regional economic development, but that the gap in disposable income between urban and rural areas combined with environmental pollution to limit regional economic development. Therefore, regional governments must continuously optimize their region's economic structure, use tax revenues rationally to solve their region's most serious problems, continuously promote trade, and narrow the gap in disposable income between urban and rural areas to solve the problem of relative poverty. Our results provide suggestions for China's regional economic development, but also provide a reference for other developing countries to mitigate poverty and achieve more sustainable regional economic development.

Keywords: regional poverty; sustainable development; market economics; urban–rural gap; social justice

1. Introduction

The development gap between countries and regions is known as "regional" or "relative" poverty (Capuno, 2022). This gap is a primary constraint on socioeconomic development around the world, especially due to the conflicts and turmoil it can cause, which have a negative impact on the peaceful development of mankind (Saboor et al., 2017; Wan et al., 2021). This impact creates obstacles to the future progress of human society (Kim et al., 2022). Therefore, international organizations such as the Food and Agriculture Organization of the United Nations, the World Bank, and governments are sparing no effort to promote more balanced development (Jenderedjian and Bellows, 2021). Ecological scientists have also carried out a series of studies on the ecological consequences of unbalanced development (Zhou et al., 2022).

However, research has lagged behind the pace of development, and this has led to international and national policy failures. In particular, the global regional development gap has widened rather than decreased, and the associated relative poverty has increased. For example, from the perspective of per capita GDP in 2021, the gap between Somalia, the world's poorest country, and Luxembourg, the richest country, has widened from US$445.8 per capita in 2021 to US$135,682.8 per capita (World Bank, 2021).

China pursued an egalitarian socialist development path during the Mao Zedong period, and regional development differences were much smaller than they are today. For example, in 1978, the lowest per capita disposable income of urban residents was 261 RMB in Guizhou Province and 412 RMB in Guangdong Province (National Bureau of Statistics, 2022). The gap was only 151 RMB. After 1978, China introduced a version of the Western market economy system as part of an effort to reform its socioeconomic system, including opening up to the outside world, and China's regional development gap widened rapidly (Chen and Haynes, 2017). In 2020, the per capita disposable income of urban residents in Guizhou Province had increased to 36,096 RMB, versus 50,257 RMB for urban residents in Guangdong Province. The gap therefore increased to 14,161 RMB. Obviously, whether in China or other countries, the development of a modern economy has not necessarily reduced the gap between the rich and the poor in different regions; rather, the gap has increased with the passage of time. This imbalance of regional economic development and the resulting social imbalance are potential causes of global conflicts, national turbulence, and perhaps even war (Li et al., 2021). Reducing regional development imbalances is therefore the foundation for peaceful global development and efforts to achieve the common goal of people around the world: an adequate income.

To solve the problems of unbalanced global and regional development and reduce the development gaps between regions within a country, we must first understand the causes of regional development differences; that is, we must understand the magnitude and causes of relative poverty. We used the term "inequality in economic development between regions" to denote relative poverty because (i) a comparison is required to assess "relative", whereas absolute poverty is defined with respect to an external standard, and (ii) because one of the goals of our paper is to demonstrate how the different regions defined in China's central planning process require different solutions. To achieve this goal, we calculated the values of key socioeconomic and environmental indicators from 2007 to 2019 for 295 Chinese cities to reveal the reasons for regional development differences. In our analysis, we added environmental indicators to the socioeconomic indicators because environmental factors are having increasingly prominent effects on regional development (Zhou er al., 2021), and governments and decision-makers are increasingly taking environmental factors into account when they formulate regional development policies (Central People's Government of the People's Republic of China, 2018). We believe the results of our study will not only provide important support for China's efforts to promote balanced regional development, but will also help other countries to solve the problem of global relative poverty.

2. Research methodology

Before we explain our analysis, it's important to explain the difference between urban and rural in the Chinese context. Unlike in most western countries, where rural areas are separate administrative regions, Chinese cities generally include both rural and urban regions within their administrative boundaries, but statistics are collected separately for the two types of regions.

2.1. Selection of indicators

We selected a range of indicators that reflected the comprehensive development of a regional economy from the perspectives of three different dimensions: per capita GDP, to represent the total economic output; per capita disposable income, to reflect personal income; and per capita retail sales of social consumer goods, to reflect social consumption activities (**Table 1**). We used the entropy method (described in Section 2.2) to estimate the weight of each dimension, and applied those weights to the raw data to create a comprehensive development index, with the regional GDP, personal income, and retail sales as the dependent variables.

Table 1. Construction of the indicators used to describe the regional development level. Weights were calculated using the entropy method.

System	Index layer	Calculation method	Weight
Regional development level	Per capita GDP	Gross domestic product/total population at the end of the year	0.3850
	Per capita disposable income	Total disposable income of residents/total population at the end of the year	0.1694
	Per capita total retail sales of social consumer goods	Total retail sales of social consumer goods/total population at the end of the year	0.4457

Source: National Bureau of Statistics (https://www.stats.gov.cn/sj/sjjd/202403/t20240327_1953908.html).

Gross domestic product (GDP) is the core index to measure the economic development of a country or region, as it reflects the economic strength of a country or region (Hao et al., 2022; Liu and Gao, 2022). However, because GDP has limitations for measuring the development of a country or region, such as the fact that it does not account for the benefits of that economic activity for citizens, we added the income of residents of a region and their total spending on social consumer goods to our analysis. The income of residents can directly reflect their quality of life (Lu et al., 2021; Niculescu-Aron and Mihaescu, 2012), and the total consumption of social consumer goods plays an important role both in promoting China's economic development and in improving the quality of life of residents (Chen et al., 2020; Pantano et al., 2022). Thus, our first-level indicators account for GDP, disposable income, and consumer spending to reflect both socioeconomic development and its human consequences.

We chose independent variables for each of these three dimensions to comprehensively reflect the importance of the key factors driving socioeconomic development: the industrialization level and environmental pollution to represent the economic structure, the trade proportion (trade as a proportion of GDP) and fiscal decentralization (delegation of some economic discretion to the provinces) to reflect market reforms, and the Internet penetration rate, medical resources, and gap between urban and rural areas to reflect social conditions (**Table 2**).

Optimizing a region's economic structure can make full use of local resources, thus promoting rapid economic development. The level of industrialization in the economy is the cornerstone of regional economic development in a developing nation such as China (Ofori et al., 2022; Tirado et al., 2016). We derived the industrialization level from the proportion of GDP accounted for by the added value created by secondary industry. As China is still a developing country, the role of secondary industry in promoting China's economic growth is still very important. In addition, environmental pollution is inevitably generated by industrialization, which damages local ecosystems and plays a negative role in regional economic development. To reflect environmental pollution, we divided the $PM_{2.5}$ concentration (the quantity of airborne particles smaller than 2.5 μm in diameter) by the per capita inhaled air volume. To solve the environmental pollution problem, it will be necessary to continuously optimize China's economic structure during regional economic development, promote the transformation of highly polluting enterprises, and help enterprises with high resource consumption transform smoothly to create less pollution. These measures will reduce environmental pollution and resource shortages, while promoting development of the regional economy (Wazza and Bedeke, 2022).

Table 2. Calculation method for the independent factors that influenced socioeconomic development.

Socioeconomic dimension	Influencing factor	Calculation method
Social conditions	Urban–rural gap	The values were measured in constant currency units rather than being adjusted for inflation, and equaled the urban per capita disposable income minus the actual rural per capita disposable income
	Internet penetration	(number of internet broadband users/resident population at the end of the year) × 10,000
	Medical resources	(number of doctors/total population at the end of the year) × 10,000
Economic structure	Industrialization level	Added value of secondary industry/regional GDP
	Environmental pollution	$PM_{2.5}$ density (the quantity of airborne particles smaller than 2.5 μm in diameter) × per capita inhaled air volume
Market reforms	Trade proportion	Total trade consumption/GDP
	Fiscal decentralization	Local fiscal expenditure/total population at the end of the year

Source: National Bureau of Statistics (https://www.stats.gov.cn/sj/sjjd/202403/t20240327_1953908.html).

China began to reform its economy and open up to the West in 1978, and the market system has developed and improved continuously since then. Market reform therefore plays a guiding role in regional economic development. Compared with the centrally planned economy that existed under Mao, a market-oriented economic system provides greater economic efficiency and promotes development of regional economies. We assumed that further optimizing the market through reforms will promote the rapid development of regional economies.

We also defined a trade index that represented the proportion of GDP accounted for by total trade consumption. This consumption includes both domestic and foreign trade, so we can better see the impact of trade on China's regional economy under the open trade conditions that have existed since 1978 (Meng et al., 2022). In China, taxes are collected by the central government. The government then provides a certain amount of decentralization of control by allocating tax revenues to regions and allowing each region to plan how it will spend the money, subject to national policy goals. Fiscal decentralization is also the financial support needed by the national government to maintain the normal operation of the whole country or region. Giving local governments a certain amount of autonomy is conducive to improving the efficiency of resource use, since local governments have a better understanding of their resource constraints and opportunities (Siburian, 2022; Song, 2013). As a fiscal decentralization index, we divided the local fiscal expenditure by the total population at the end of the year. Using this index can reflect the utilization of tax revenues by local governments.

Social conditions are the foundation of a regional economy and an important guarantee of regional economic development. The Internet penetration rate reflects scientific and technological progress and innovation, which will be further promoted as Internet access increases (Elgin, 2013). We represented the Internet penetration rate as the number of Internet broadband access users divided by the resident population at the end of the year (to facilitate comparison between data for different cities), then multiplied the result by 10,000. The development of health care provides a basic medical guarantee to protect the health of the residents who are responsible for economic development. To reflect medical resources, we divided the number of doctors by the total population at the end of the year (to facilitate comparison between data for different cities), then multiplied the result by 10,000.

Since 2003, the medical problems in rural society have attracted the central government's attention (Ren et al., 2022). Although the government has achieved full regional coverage by building more hospitals and clinics, the numbers of doctors and other medical professionals have not increased. This has led to a widening shortage of doctors as populations have increased. Until now, full coverage by rural medical assistance has been achieved, but there has been little change in per capita rural medical resources. This has led to a widening gap between urban and rural areas.

We quantified the urban–rural income gap using the difference between the per capita income of urban and rural residents in a given year without accounting for inflation, which directly represents the economic differences between urban and rural areas.

2.2. Data sources and data processing

Based on the availability of the data described in the previous section and the criterion that there were no city-specific national policies designed to promote total development in a city, we selected 295 prefecture-level administrative regions as research samples. These included different types of administrative region, such as prefecture-level cities, regions, autonomous prefectures, and leagues. The source of the data was China's National Bureau of Statistics (https://www.stats.gov.cn/sj/). We selected a random sample of all Chinese cities. For simplicity, we will refer to all of these different administrative areas as cities. We excluded some administrative regions that were greatly affected by government policies, such as Beijing, Xiamen, and Tianjin, to provide a fair comparison between the city's data and data from other cities unaffected by such policies.

We selected data from 2007 to 2019 as the research period because China's central government did not explicitly track urban–rural differences for individual cities until 2007. This tracking began in 2007 because in 2006, China began to implement an overall regional development strategy in the "Eleventh Five-Year Plan for National Economic and Social Development".

Because the seven indicators used different units of measurement and had different magnitudes of values, it was necessary to standardize them before they could be integrated into a single comprehensive index. We therefore standardized all data using the following formula:

$$Z_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_j) - \min(X_j)} \quad (1)$$

where X_{ij} is the original value of index *j* for sample (city) *i*, and $\max(X_j)$ and $\min(X_j)$ represent the maximum and minimum values of index *j* in all samples.

We used the entropy method to assign the weights of the three first-level indexes (per capita GDP, per capita disposable income, and per capita total retail sales of social consumer goods). We then multiplied the values of these indexes by the corresponding weight, and summed them to create a comprehensive development index for the regional economy, which served as the dependent variable. In the entropy method, variables that have a wider range of values (Liu et al., 2021) explain more of the variation in the overall dataset, and should therefore receive a heavier weight. The calculation equations are as follows:

$$Y_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{m} Z_{ij}} \quad (2)$$

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} Y_{ij} \ln Y_{ij} \quad (3)$$

$$f_j = 1 - e_j \quad (4)$$

$$W_j = \frac{f_j}{\sum_{j=1}^{n} f_j} \quad (5)$$

$$U = \sum_{j=1}^{n} W_j Z_{ij} \quad (6)$$

where Y_{ij} is the information entropy of index *j* for sample (city) *i*, Z_{ij} is the standardized value of index *j* for sample (city) *i*, e_j is the information entropy of index *j*, f_j is the redundancy of the information entropy, w_j is the weight of index *j*, and *U* is the comprehensive evaluation index, which represents the overall level of regional economic development.

We used the average annual growth rate of the indicators from 2007 to 2019 in our empirical analysis, and carried out spatially explicit regression of the cross-sectional data. Then, to account for the time lag between proposing and implementing policies, we calculated the average annual growth rate of the indicators from 2007 to 2019 as the data source, and performed a spatial regression of the cross-sectional data with time lags of 1, 2, and 3 years. Examining the effects of lagged variables at different time intervals let us capture the dynamic nature of the relationships between variables over time. However, our analysis focused on the relative contributions of each driving factor to the overall comprehensive index. Quantifying the specific interactions between factors (e.g., how much one factor changes in response to changes in another factor) will be a challenge for future research.

In addition, to account for the different resource conditions, regional policies, and development differences in different regions of China, we calculated the average annual growth rate for the 12 years from 2007 to 2019 as the data source for the indicators, and divided China into eastern, central, western, and northeastern regions to support the central government's planning based on a classification by the Chinese Bureau of Statistics, and then repeated the spatial regression separately for each region.

Finally, we repeated the analysis for big, medium, and small cities, with their size based on the criteria issued by China's State Council. (These sizes are defined in section 2.3.).

2.3. Empirical analysis

We used spatial correlation analysis because in examining regional patterns, we should consider the spatial connections among regions, clustering patterns, and heterogeneity, since this provides stronger insights into correlations among natural and socioeconomic phenomena. In this paper, we used Moran's global *I* and local *I* to analyze the strength of the spatial correlations with China's regional comprehensive economic development index. The global *I* measures the relationship among spatial factors as a whole. If the value is statistically significant, this shows overall autocorrelation, with a value less than 0 indicating a negative spatial correlation, and a value greater than 0 indicating a positive spatial correlation; a value of 0 indicates no spatial correlation. The calculation formula is as follows:

$$I = \left(\frac{N}{\sum_i \sum_j W_{ij}}\right)\left(\frac{\sum_i \sum_j W_{ij}(X_i - \bar{X})}{\sum_i (X_i - \bar{X})^2}\right) \tag{7}$$

where *I* is the global Moran index, X_i is the observed value in region *i*, $\bar{X}$ is the mean value for all regions, and w_{ij} is an element in a binary matrix that contains values of 0 for cities that are not adjacent to each other and 1 for cities that are adjacent; and *N* is the total number of research samples (i.e., cities).

The local Moran's *I* can measure the degree of spatial correlation between each region and its surrounding areas on a local scale, and reveals the heterogeneity of spatial differences (Anselin, 1995). The calculation formula is as follows:

$$I_i = \frac{n(X_1 - \bar{X}) \sum_i W_{ij}(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2} \tag{8}$$

where I_i is the local Moran index, X_i is the observed value in city *i*, $\bar{X}$ is the mean value for each area, w_{ij} is a binary full-value matrix of adjacent spatial distances, which defines the mutual adjacency of spatial units (e.g., 295 cities); and *N* is the total number of research samples (i.e., cities).

Next, we performed a spatially explicit econometric analysis. We used version 1.18.0 of the Geoda software (https://geodacenter.github.io/) for regression analysis. First, we created a spatial weight matrix. We then carried out ordinary least-squares (OLS) regression (using Equation (9), later in this section), and performed spatial autocorrelation diagnosis using lag tests. If the LM-lag test result is significant and the LM-error is not significant, then a spatial lag model (SLM, using Equation (10) later in this section) should be used. If LM-lag is not significant and LM-error is significant, then a spatial error model (SEM, using Equation (11) later in this section) should be used. If both are significant, then further analysis should be performed and we will choose the robust LM-lag or robust LM-error tests. If the Robust LM-lag result is significant, then the SLM should be used; if the robust LM-error is significant, the SEM should be used. If neither result is significant, then simple OLS regression can be used for the analysis. The ordinary least-squares regression is defined as follows:

$$Y = X\beta + \epsilon \tag{9}$$

where *Y* refers to the dependent variable vector, *X* refers to the explanatory variable matrix, β is the estimated coefficient vector, and ε is the error term vector. The spatial lag model (SLM) is defined as follows:

$$Y = \rho WY + X\beta + \epsilon \tag{10}$$

where ρ is the coefficient of the spatial lag term, WY refers to the product of the spatial weight matrix and the dependent variable, and represents the spatial lag of the dependent variable. The spatial error model (SEM) is defined as follows:

$$Y = X\beta + \mu \tag{11}$$

$$\mu = \lambda W\mu + \epsilon \tag{12}$$

where μ refers to the error term with spatial autocorrelation, λ refers to the coefficient of spatial autocorrelation error, $W\mu$ is the product of the spatial weight matrix and ϵ is the error term, which represents the spatial autocorrelation of the error term.

Finally, to reflect the influence of different factors on regional economic development more accurately and intuitively, we used the absolute value of the regression coefficients to calculate the strength of the contribution of each variable to regional economic development (Cao et al., 2014). The calculation formula is:

$$Con_K = \frac{AC_K}{\sum_{K=1}^{K} AC_K} \times 100\% \tag{13}$$

where Con_K represents the contribution of variable K to dependent variable Y, and AC_K represents the absolute value of the coefficient β_K.

2.4 China's urban division method

In November, 2014, China's State Council issued the "Notice on Adjusting the Standards of City Scale Classification", which classified the city scale into five categories and seven grades. Considering the lack of some data for some cities and the difficulty in obtaining other data that is required to classify the cities, we divided Chinese cities into three categories according to the 2010 data and the standards issued by the State Council. This left us with 64 big cities, 84 medium-sized cities, and 147 small cities, totaling 295 cities. Megacities, metropolises, and big cities were collectively referred to as big cities in this paper. Specifically, we defined a big city as a city with an urban population of more than 1 million, a medium-sized city as a city with an urban population of between 500,000 and 1 million, and a small city as a city with an urban population of less than 500,000.

3. Results

Table 3 shows the results of the OLS regression and the SEM regression. The proportion of trade played the most important role in promoting regional economic development, with significant positive contributions of 40.7% and 39.7% for OLS and SEM, respectively, followed by medical resources (16.3% and 15.9%) and fiscal decentralization (11.5% and 10.6%). The urban–rural gap had a strong and significant inhibitory effect (15.6% and 17.4%) on regional economic development. Environmental pollution had no significant effect.

Given that the influencing factors in one year may also have an impact on subsequent years, we also examined the effects with time lags of 1, 2, and 3 years (**Table 4**). The trade proportion again had the most important effect at all three times lags, with its contribution reaching 51.1% and 49.4% in the OLS and SEM regressions, respectively, at a lag of 3 years. In the OLS regressions, the next-strongest contribution was from medical resources (17.0%, 16.7%, and 15.5% for time lags of 1, 2, and 3 years, respectively), whereas the contribution of industrialization level (11.3%) was strongest with a time lag of only 1 year. The corresponding SEM results were similar.

Table 3. Results of the empirical analysis. β_K, regression coefficient; Con, contribution; OLS, ordinary least-squares regression; SEM, spatial error model. Factors are defined in **Table 2**.

Influencing factor	**OLS (R^2 = 0.51, p < 0.05)**		**SEM (R^2 = 0.53, p < 0.05)**	
	β_k	**Con (%)**	β_k	**Con (%)**
Internet penetration	0.087*	5.26	0.103**	6.06
Medical resources	0.269**	16.26	0.271**	15.94
Industrialization level	0.166**	10.04	0.162**	9.53
Trade proportion	0.673**	40.69	0.674**	39.65
Fiscal decentralization	0.190**	11.49	0.180**	10.59
Urban–rural gap	–0.258**	15.60	–0.296**	17.41
Environmental pollution	–0.011ns	0.67	–0.014ns	0.82

Note: + indicates p < 0.1; * means p < 0.05; ** indicates p < 0.01; ns means not significant.

Table 4. Empirical analysis results that accounted for the time lag effect. β_K, regression coefficient; Con, contribution; OLS, ordinary least-squares regression; SEM, spatial error model.

Influencing factor	**1-year lag**				**2-year lag**				**3-year lag**			
	OLS (R^2 = 0.52, p < 0.05)		**SEM (R^2 =0.54, p < 0.05)**		**OLS (R^2 = 0.54, p < 0.05)**		**SEM (R^2 = 0.56, p < 0.05)**		**OLS (R^2 = 0.51, p < 0.05)**		**SEM (R^2 = 0.53, p < 0.05)**	
	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**
Internet penetration	0.052ns	3.23	0.058ns	3.56	0.050ns	3.01	0.063ns	3.73	0.056ns	3.74	0.070+	4.54
Medical resources	0.273**	16.97	0.269**	16.51	0.277**	16.67	0.271**	16.05	0.233**	15.54	0.222**	14.40
Industrialization level	0.181**	11.25	0.182**	11.17	0.140**	8.42	0.146**	8.65	0.064ns	4.27	0.073+	4.73
Trade proportion	0.704**	43.75	0.703**	43.16	0.785**	47.23	0.782**	46.33	0.766**	51.10	0.762**	49.42
Fiscal decentralization	0.069ns	4.29	0.070ns	4.30	0.073ns	4.39	0.065ns	3.85	0.082ns	5.47	0.076ns	4.93
Urban–rural gap	–0.316**	19.64	–0.343**	21.06	–0.331**	19.92	–0.361**	21.39	–0.294**	19.61	–0.331**	21.47
Environmental pollution	0.014ns	0.87	0.004ns	0.25	0.006ns	0.36	–0.000ns	0	0.004ns	0.27	–0.008ns	0.52

Note: + indicates p < 0.1; * means p < 0.05; ** indicates p < 0.01; ns means not significant.

Because the resources and associated government policies differed among the regions, we repeated our analysis for eastern, central, western, and northeastern China (**Tables 5** and **6**). In eastern China, fiscal decentralization (35.8%% and 35.4% for the OLS and SEM regressions, respectively) played the greatest role in promoting regional economic development. This was followed by the trade proportion (17.0% and 12.3%). The eastern region is more developed than the other regions, with higher economic vitality and a stronger industrial foundation. There, fiscal decentralization can further unleash the region's economic potential, promoting faster and more sustainable economic growth. In central China, industrialization level played the greatest role (26.8% and 26.7%). This was followed by medical resources (22.6% and 21.2%). The central region's location provides transportation and logistics advantages, and facilitates the transportation and distribution of industrial products among the other regions. In addition, compared to the eastern region, the central region may have relatively lower labor costs, which attracts enterprises to invest in the region and produce their products. These factors collectively contributed to industrialization playing the most significant role in the central region compared to the other regions. In both western and northeastern China, the trade proportion was most important (47.8% and 46.3%, respectively, for OLS and 50.1% and 51.4% for SEM). This was followed by medical resources (23.0% and 22.1%) in western China and industrialization level (20.8% and 20.2%) in northeastern China.

Table 5. Results of the empirical analysis for eastern and central China. β_K, regression coefficient; Con, contribution; OLS, ordinary least-squares regression; SEM, spatial error model.

Influencing factor	**Eastern region**				**Central region**			
	OLS (R^2 = 0.65, p < 0.05)		**SEM (R^2 = 0.73, p < 0.05)**		**OLS (R^2 = 0.40, p < 0.05)**		**SEM (R^2 = 0.42, p < 0.05)**	
	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**
Internet penetration	0.147**	7.53	0.108**	5.28	0.028ns	5.60	0.028ns	5.53
Medical resources	0.037ns	1.90	–0.137ns	6.70	0.113**	22.60	0.107**	21.15
Industrialization level	0.042ns	2.15	–0.025ns	1.22	0.134**	26.80	0.135**	26.68
Trade proportion	0.332**	17.02	0.251**	12.27	0.023+	4.60	0.025*	4.94
Fiscal decentralization	0.698**	35.78	0.724**	35.40	0.091**	18.20	0.096**	18.97
Urban–rural gap	–0.544**	27.88	–0.656**	32.08	–0.071**	14.20	–0.075**	14.82
Environmental pollution	–0.151**	7.74	–0.144**	7.04	–0.040**	8.00	–0.040**	7.91

Note: + indicates p < 0.1; * means p < 0.05; ** indicates p < 0.01; ns means not significant.

Table 6. Results of the empirical analysis for western and northeastern China. β_K, regression coefficient; Con, contribution; OLS, ordinary least-squares regression; SEM, spatial error model.

Influencing factor	**Western region**				**Northeast region**			
	OLS (R^2 = 0.73, p < 0.05)		**SEM (R^2 = 0.74, p < 0.05)**		**OLS (R^2 = 0.35, p < 0.05)**		**SEM (R^2 = 0.37, p < 0.05)**	
	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**	β_k	**Con (%)**
Internet penetration	0.134**	10.19	0.157**	11.64	–0.106ns	5.33	–0.107ns	5.61
Medical resources	0.302**	22.97	0.298**	22.09	0.091ns	4.57	0.066ns	3.46
Industrialization level	0.102**	7.76	0.111**	8.23	0.413**	20.75	0.386**	20.24
Trade proportion	0.628**	47.76	0.625**	46.33	0.996**	50.05	0.980**	51.39
Fiscal decentralization	0.132**	10.04	0.123**	9.12	0.337**	16.93	0.321**	16.83
Urban–rural gap	0.015ns	1.14	0.029ns	2.15	0.019ns	0.95	0.025ns	1.31
Environmental pollution	–0.002ns	0.15	–0.006ns	0.44	0.028ns	1.41	0.022ns	1.15

Note: + indicates p < 0.1; * means p < 0.05; ** indicates p < 0.01; ns means not significant.

Table 7 presents the results for our analysis based on city size. For big cities, fiscal decentralization (31.0% and 30.9% for OLS and SLM, respectively) played the most important role in promoting regional economic development, followed by industrialization level (26.2% and 27.2%) and trade proportion (21.4% and 22.2%).

Environmental pollution (7.1% and 7.4%) had a significant inhibitory effect on economic development, which differs from our overall results (**Table 3**). For medium and small cities, trade proportion had the strongest contribution to economic development, but with a larger contribution for medium cities (56.4% and 56.7%) than for small cities (29.7% and 30.0%). In small cities, the urban–rural gap had a strong inhibitory effect on economic development (29.7% and 29.5%), versus a small (<4%) contribution for medium and big cities.

Table 7. Empirical analysis results for big, medium, and small cities in China. β_K, regression coefficient; Con, contribution; OLS, ordinary least-squares regression; SEM, spatial error model; SLM, spatial lag model.

Influencing factor	Big city				Medium-sized city				Small city			
	OLS ($R^2 = 0.46$, $p < 0.05$)		SLM ($R^2 = 0.50$, $p < 0.05$)		OLS ($R^2 = 0.66$, $p < 0.05$)		SEM ($R^2 = 0.66$, $p < 0.05$)		OLS ($R^2 = 0.65$, $p < 0.05$)		SLM ($R^2 = 0.66$, $p < 0.05$)	
	β_k	Con (%)	β_k	Con (%)	β_k	Con (%)	β_k	Con (%)	β_k	Con (%)	β_k	Con (%)
Internet penetration	0.02+	2.38	0.02ns	2.47	–0.02ns	1.23	–0.01ns	0.61	0.12**	6.03	0.12**	6.00
Medical resources	0.07+	8.33	0.06+	7.41	0.07ns	4.29	0.06ns	3.66	0.31**	15.58	0.31**	15.50
Industrialization level	0.22**	26.19	0.22**	27.16	0.29**	17.79	0.30**	18.29	0.18**	9.05	0.18**	9.00
Trade proportion	0.18**	21.43	0.18**	22.22	0.92**	56.44	0.93**	56.71	0.59**	29.65	0.60**	30.00
Fiscal decentralization	0.26**	30.95	0.25**	30.86	0.29**	17.79	0.29**	17.68	0.16**	8.04	0.16**	8.00
Urban–rural gap	–0.03ns	3.57	–0.02ns	2.47	0.01ns	0.61	0.02ns	1.22	–0.59**	29.65	–0.59**	29.50
Environmental pollution	–0.06**	7.14	–0.06**	7.41	–0.03ns	1.84	–0.03ns	1.83	–0.04ns	2.01	–0.04ns	2.00

Note: + indicates $p < 0.1$; * means $p < 0.05$; ** indicates $p < 0.01$; ns means not significant.

4. Discussion

The trade proportion had the strongest influence on regional economic development (**Table 3**), which shows that domestic and foreign trade have strongly influenced China's economic development. With the development of globalization, no country can be fully independent, so all economic development will benefit from participating in global trade. On the other hand, given the enormous market created by China's population, domestic trade has also strongly promoted China's economy, and has given China certain advantages. Therefore, China should open up more to the outside world and continuously promote global integration, without neglecting the importance of the country's domestic market. To account for unbalanced international trade and environmental issues, we recommend that China strengthen international cooperation and communication, while seeking ways to reduce the environmental impact of this trade. This will facilitate the establishment of a fair, open, and inclusive international trade system, enabling joint efforts to address global challenges and achieve mutual development and prosperity.

When we accounted for lag time (**Table 4**), the contribution of trade proportion to regional economic development remained important for a lag of at least 3 years, and its contribution increased with increasing lag time, indicating that the influence of trade, over several years, strongly promoted regional economic development. The urban–rural gap strongly inhibited regional development both in the current year and when we accounted for time lags (**Tables 3** and **4**), and the effect remained strong (a contribution > 19%) even with a time lag of 3 years. This indicates that increasing the urban–rural gap will have a strong cumulative negative effect on regional economic development. If this gap is not decreased, it may lead to a vicious circle, in which a scarcity of resources in rural areas leads to further concentration of resources in urban areas, which weakens the competitiveness of rural areas, thereby encouraging the resources to flow to urban areas. This is likely to lead to unemployment and social unrest in rural areas, and our results show that this will inhibit sustained development of the rural economy.

Due to the influence of large differences in natural and historical factors among China's regions, different factors impede social and economic development in each region. For example, the gap between urban and rural areas is wide in the highly developed eastern and central regions of China, whereas the negative impact of environmental pollution is stronger in the western and northeastern regions (**Tables 5** and **6**). Technological progress (Internet penetration and industrialization) was important in the densely populated eastern region, but it was more important in the sparsely populated western region, where transportation is more difficult (**Tables 5** and **6**). Our regional analysis reveals variation among regions in the most important factors, which suggests that different regions should adopt different strategies to deal with their unique constraints and opportunities instead of blindly copying the experience of other regions to achieve sustainable development of their society and economy. Technological innovation and investment in education will also be crucial in reducing the gap between regions (Guo and Sun., 2016; He et al., 2017). We recommend that the government increase investment in education and technological innovation, cultivate promising new talents to enhance technological innovation capabilities, promote the transformation and upgrading of a region's economic structure to take advantage of these capabilities, and thereby achieve sustained development.

Economic development, social services, and environmental impacts all affect a region's or country's social progress (Dong et al., 2022). As our calculations showed, the popularization of the Internet, the improvement of medical care, the development of industrialization, and the adoption of market mechanisms all played a significant role in promoting regional social and economic development. In contrast, increasing the urban–rural gap hinders development (**Table 3**). The widening gap between urban and rural areas increases resentment among rural residents who desire a better standard of living, and this can lead to social unrest (Liu and Zhang, 2022; Zhang et al., 2022a). At the same time, much of the labor force from poor areas has migrated to wealthier urban areas, and this loss of labor and income is unfair to the poor areas. Less-developed areas bear an additional training cost to replace the lost workers and cannot obtain the wealth that would have been created by these lost workers. In effect, this represents exploitation of the poor areas by the wealthier areas. To mitigate the urban–rural development gap, we recommend that the government implement policy measures to promote rural development and thereby provide a balance with urban development. For instance, promoting infrastructure construction in rural areas will improve access to markets, and improving public services such as medical resources will make rural areas more attractive places to live and will promote rural economic development and increase rural income.

Environmental pollution not only reduces land productivity, but also affects agricultural production, thereby increasing poverty among rural residents (Zhang et al., 2022b). Air pollutants directly endanger human health, which not only increases the medical and health costs to the residents affected by the pollution, but also reduces the input from the labor force, creating a potentially huge negative impact on social and economic development (Li et al., 2022). In the past few decades, the transfer of highly polluting industries from developed areas (mostly in the east) to poor areas (mostly in the west) represents environmental exploitation of the less-developed areas. However, we found that environmental pollution was most serious in eastern and central China (**Tables 5** and **6**), presumably because of the higher population density and greater concentration of industry. If less-developed areas want to achieve sustainable social and economic development, they must nonetheless avoid the negative impact of environmental pollution to ensure that it does not become a more serious problem as their population increases and industry expands. The environmental pollution caused by China’s potentially excessive urbanization and industrialization, the government should strengthen environmental protection policies and regulatory efforts, promote green development, facilitate the optimization and upgrading of the industrial structure, and thereby reduce the negative impacts of development on the environment.

The trade proportion (a continuing increase) and the urban-rural gap (a continuing strong negative effect) showed a time lag effect. Development of the Internet, medical resources, industrialization, and market development, and the gap between urban and rural areas, are all affected by technological progress (Agasisti and Bertotetti, 2020), and this will not only affect the regional economic and social development in the current year, but will also affect development in subsequent years (di Maria et al., 2012), possibly due to cumulative effects. Cumulative effects will further widen the gap between urban and rural development, resulting in a vicious circle of geographical poverty. Therefore, to reduce the development gap between regions, we should examine the present results to identify the key factors in each region or city that should be promoted to stimulate development and should mitigate the negative factors that interfere with development.

The widespread implementation of subsidies to agriculture and other industries in developed countries (Bai et al., 2022; Guo et al., 2021) has created an invisible tax on developing countries, which may lack these subsidies and therefore have a higher product price. This is not accounted for in our data sources, and may have created a gap between the data we analyzed and the real value, which would affect the related calculation results. In future research, a way must be found to account for these effects. In addition, economic development in China has led to potentially excessive urbanization and environmental pollution caused by over-industrialization, and both processes have had a negative impact on regional development (Tong et al., 2022). To promote fairer development of human society, developed countries and regions within a country should avoid policies that increase regional imbalances and the urban–rural gap. This could be achieved by controlling commodity prices (for example, by subsidizing agriculture and exports) and other mechanisms. They should also avoid policies that lead to economic development by damaging the environment, as in the abovementioned example of moving highly polluting industries to less-developed areas rather than reducing pollution at their current location. This exported pollution will further widen regional development differences. Other factors, such as education and transportation infrastructure, were less important than the factors we analyzed, but their importance should nonetheless not be neglected.

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