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# Research on the economic effect of employment structure change in heterogeneous regions: evidence from resource-based cities in China

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## ABSTRACT

The Report on the Work of the Chinese Government in 2021 emphasised that stable employment is the foundation of national development. Therefore, adjustment of the employment structure is one of the main routes for sustainable development of resource-based cities. However, the impact of employment structure on sustained economic growth, particularly in heterogeneous regions, has not yet been determined. This study analyses China's employment structure's spatial evolution, using panel data from 2004 to 2018 of 115 prefecture-level resource-based cities. It explores the driving factors and spatial effects of employment structure changes on economic growth through an extended two-sector economic growth model and spatial econometric model, and proposes solutions for heterogeneous regions. The results show that the labour productivity of the employed population in the secondary industry is the most important factor affecting economic growth, but the spatial effects of employment structure adjustment on economic growth are different in heterogeneous regions. They further reveal that improving the productivity of the employed population in the secondary industry and building an industrial system according to regional advantages are the top priorities for developing the sustainable economy of resource-based cities.

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## 1. Introduction

Resource-based cities are an essential strategic support base for China's energy resources and an important support for sustained and vigorous development. However, the historical problems of resource-exhausted cities are serious and need to be solved. The problems of shantytown renovation, subsidence area management,

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employment of unemployed miners, and protection of urban low-income people need to be addressed. Emerging industries in resource-based cities are at the initial stage, and the development of alternative industries lags, making it difficult to sustain economic growth, and easy to fall into the 'resource curse'. Innis (1999), a famous Canadian economic historian and economic geographer, pioneered research on such problems as early as the 1930s. The existing comprehensive theoretical research (e.g., Liu et al., 2011, 2013; Zhu, 2014; Ruan et al., 2020 ) and empirical analysis (Ćopić et al., 2014; He et al., 2017; Li et al., 2016; 2021) have been relatively rich and covered aspects such as resource-based city planning, transformation models and sustainable development. Research on resource-based cities in Chinese academia began after 1949 and focused on the national overall development strategy prepared by the government during the planned economic period. After the economic reform and opening up of China, it focused on all aspects of the development of resource-based cities, especially transformation performance, coordinated and integrated development, reemployment of urban labour force, and industrial structure adjustment (Cai & Wu, 2005; Gu et al., 2013; Jing & Wang, 2020; Liu et al., 2020).

Lewis (1954), a pioneer in the study of economic problems in developing countries, put forward a dual economic model to explore the impact of sectoral structure changes on economic growth. Chenery et al. (1986), Kuznets (1965), Rostow (1990), *etc.* determined that the change in department structural composition brought about economic growth through research. After World War II, the digital revolution began, and the tertiary industry developed rapidly. From the 1980s to the 1990s, with the adjustment of China's economic structure and the transformation of the economic growth model, Chinese scholars began to pay attention to the relationship between employment structure and economic growth. Many studies have shown that the transfer of labour from agriculture to industry and service will promote national economic growth (Brandt et al., 2008; Cai & Wang, 2010; Echevarria, 1997; Fan et al., 2001; Ghose, 1990; Sposi, 2019).

In 2013, the State Council of China issued 'The Plan of Sustainable Development for Resource-based Cities in China (2013–2020)' (hereinafter referred to as 'the Plan') to guide the sustainable development of various resource-based cities across the country, yielding remarkable achievements. After the initial capital accumulation, the urban industrial structure was transformed, and the employment structure adjusted accordingly. Against the background of actively implementing the employment priority strategy in China, employment capacity continued to expand. As part of China's urban system, resource-based cities studied the characteristics of their employment structure and its impact on economic growth, which helps analyse issues related to sustained economic growth.

## 2. Literature review

Previous studies have revealed the economic effects of changes in the employment structure from different perspectives. The first is the interactive effect. Fan et al. (2001) show that with rapid economic growth, great changes have taken place in China's industries and employment structure since 1978. Zhang et al. (2020) postulate

that the interaction between economic growth and employment structure has both positive and negative aspects. The performance varies in different periods of development, and the overall relationship is an inverted 'U'. Since 1978, the agricultural employment population has continued to shift to non-agricultural industries, and the temporary demographic dividend has greatly promoted rapid economic growth. After 2011, rural surplus labour was gradually absorbed by the industrial sector, the demographic dividend began to disappear, and China's economic growth rate declined.

The second is the relation effect. Changes in the employment structure are triggered by economic development, which significantly increases the economic growth rate. Chenery et al. (1986) and Solow (1970) confirm that economic growth drives structural adjustment. Adjusting the employment structure, which is the reallocation of resources, begets further economic development. Liu et al. (1999) demonstrate that rapid economic growth is characterised by significant changes in the employment structure of various industries in China, and the changes have obvious regional differences. In brief, rapid economic growth leads to significant changes in the national economic structure, which are closely related to changes in the employment structure.

Another view is about the elastic effect. Cai (2010) shows that full employment is a source of economic growth and maximising employment is the key to maintaining the population's role in promoting economic growth. Cai and Wang (2010) provide detailed statistics on the problems, and confirm that China's forceful economic growth has been accompanied by the simultaneous expansion of employment, and the diversification of the employment structure has also been significantly reflected since 1978. Kuznets and Murphy (1966), and Ray et al. (2017) show that a rationalised employment structure can drive the transformation of the economic growth model.

Additionally, there is a view of the intermediary effect. Romer (1986) and Lucas (1988) established a theoretical model of endogenous economic growth by taking technological progress as an endogenous variable, which theoretically proves that technological progress can promote industrial structure adjustment and transform economic growth patterns, thereby affecting employment structure and ultimately promoting economic growth. He and Lan (2020) found that the interaction effect between research and development intensity and the proportion of the employment population in the tertiary industry has a significant effect on promoting economic growth, while the interaction effect with the proportion of the employment population in the primary and secondary industries does not.

Existing studies are also more comprehensive on countries at different stages of development, and mainly focus on the coordinated development of employment structure and economic growth. Studies have been conducted in developed countries (e.g., Dietrich, 2012; Hartwig, 2012; Lains, 2006; Sposi, 2019) and developing countries (e.g., Dobrescu, 2011; Francois & Abimbola, 2019; Jula & Jula, 2013; Yu & Xu, 1999). Although most existing studies have examined the positive influence of employment structure on economic growth in different regions, debates and disagreements persist (Cheong & Wu, 2014). Research on evolution characteristics has gradually changed from qualitative to quantitative descriptions. As for the influence

mechanism, as the spatial model can reflect the spatial difference of influencing factors more accurately, the research method has changed from the traditional to a spatial statistical method (Gu & Wu, 2019).

However, studies on the impact of employment structure on economic growth using spatial models with spatial weights are rare. The research on economic growth and employment structure is mostly carried out from the macroscopic national perspective, while the research on employment structure and economic growth in the process of transformation and development of resource-based cities is less from the prefecture-level scale. And existing studies do not classify cities according to resource types, so it is difficult to provide specific policy recommendations for cities with different resource types.

Although the population and economic scale of resource-based cities are not large, what urgently needs to be solved is the surplus of labour and reemployment caused by the inability of the original pillar industries to meet the development needs of the new era during the transformation process. Therefore, it is more practical to study the population and economic development of resource-based cities from the perspective of employment structure.

### 3. Theoretical framework

#### 3.1. Basic model

Accelerated economic growth has led to a transformation of underemployed primary sector labour to the higher-productivity secondary and tertiary sectors, resulting in structural changes in employment. With increased capital investment, technological progress, or greater openness to international trade, changes in employment structure have affected economic growth. The practice of Temple and Wößmann (2006) can be used to establish an economic growth model based on dual economic structure theory. Assuming that the total employed population is  $L$ ,  $L_a$  represents the employed population of primary industry (traditional sector),  $L_b$  represents the employed population of the secondary and tertiary industries (modern sector).

$$L=L_a + L_b \quad (1)$$

Assuming that the output of the traditional sector is  $Y_a$ , the output of the modern sector is  $Y_b$ . Interestingly, the productivity of the traditional sector is  $\Phi_a$ , the productivity of the modern sector is  $\Phi_b$ . The factors of production in both sectors contain capital investment  $K$ , the level of technological progress  $A$ , and labour supply  $L$ . When capital and labour are equally intensive, technological progress is Hicks-neutral,  $F$  is the rule of function correspondence, and the production function can be expressed as follows.

$$Y_a = A_a \cdot F(K_a, L_a) \quad Y_b = A_b \cdot F(K_b, L_b) \quad (2)$$

It is assumed that the wages of the employed population in both sectors are set according to the marginal output, and the wage differential is the determining factor

influencing the transfer of employment. Lower labour productivity implies lower wages, and the two are positively correlated. Compared with the secondary and tertiary industries, the labour productivity of the employed population in the primary industry is lower ( $\Phi_a < \Phi_b$ ). When the economy is in long-run equilibrium, the ratio of labour productivity  $q$ , and the probability of labour migration  $p$  can be expressed.

$$q = \frac{\Phi_b}{\Phi_a} \qquad p = \frac{\omega \left( \frac{\Phi_b}{q\Phi_a} - 1 \right)}{1 + \omega \left( \frac{\Phi_b}{\Phi_a} - 1 \right)} \tag{3}$$

The parameter  $\omega$  in Equation (3) is the speed of adjustment of the economic system to long-run equilibrium. Thus, the quantitative relationship between labour productivity in the two sectors can be expressed as Equation (4).

$$\Phi_b = q \left[ 1 + \frac{1}{\omega} \left( \frac{p}{1-p} \right) \right] \cdot \Phi_a \tag{4}$$

Assuming that capital flows freely between sectors, the capital profit rate is also determined by marginal output. Thus, without considering the rate of depreciation of capital, the total output of the economy  $Y$  can be expressed.

$$Y = \Phi_a L_a + \Phi_b L_b + r_a K_a + r_b K_b \tag{5}$$

$r$  is the capital profit rate and  $r_a=r_b$ .  $s$  is the share of traditional sector output in total economic output.  $\eta$  is the share of labour output in total economic output, from which the economic growth rate can be determined.

$$\begin{aligned} \frac{Y^\bullet}{Y} &= s \frac{Y_a^\bullet}{Y_a} + (1-s) \frac{Y_b^\bullet}{Y_b} \\ &= s \frac{A_a^\bullet}{A_a} + (1-s) \frac{A_b^\bullet}{A_b} + (1-\eta) \left( \frac{K_a^\bullet}{K} + \frac{K_b^\bullet}{K} \right) + \frac{\Phi_a L}{Y} \cdot \frac{L_a^\bullet}{L} + \frac{\Phi_b L}{Y} \cdot \frac{L_b^\bullet}{L} \end{aligned} \tag{6}$$

By substituting Equation (1) and (3) into Equation (6), Equation (7) can be obtained.

$$\frac{Y^\bullet}{Y} = s \cdot \frac{A_a^\bullet}{A_a} + (1-s) \cdot \frac{A_b^\bullet}{A_b} + (1-\eta) \cdot \frac{K^\bullet}{K} + \frac{\Phi_a L_a}{Y} \cdot \frac{L^\bullet}{L} + \frac{L_b^\bullet}{L} \cdot \left[ q - 1 + \frac{qp}{\omega(1-p)} \right] \tag{7}$$

The last term of Equation (7) captures the economic increment caused by the transformation of the employed population. The analysis shows that when the increment of  $L_b$  is greater than zero, the employed population will shift from the primary industry to the secondary and tertiary industries, and the adjustment of the employment structure will promote economic growth.

### 3.2. Further development and explanation

The theoretical model reflects that economic growth is driven by three effects: total factor productivity, capital and labour input, and employment structure changes. In the long run, technological progress ( $A$ ) is a source of economic growth. To accelerate economic growth, cities will first invest in new capital and develop until economic growth stagnates. Thus, it is necessary to invest in new technologies to promote innovation and improve economic development. Fan et al. (2017) showed that government support for innovation significantly impacted on economic growth in labour-intensive and capital-intensive state-owned sectors.

In the short term, capital investment ( $K$ ) significantly impacts social output and employment. Strengthening capital investment can promote urban capital accumulation, accelerate the construction of supporting infrastructure, and promote large-scale production enterprises. Subsequently, as the employment structure is adjusted, productivity is concentrated and distributed in different regions, and economic strength is greatly improved. When the proportion of investment increases, the per capita capital stock increases as the per capita output growth rate. Labour input ( $L$ ) can be influenced by human capital input, the level of human capital, and labour supply. Barro and Martin (1995) emphasised the importance of human capital input or the efficiency of the education sector in increasing the rate of consumption growth and economic growth. Improving the level of human capital will effectively increase the labour supply by increasing labour productivity, thereby promoting urban economic growth (Stanković et al., 2021). Population growth is also a source of economic growth (Cai, 2010). In an atmosphere of steady economic growth, as the labour force increases, the total output also increases at the same rate. Therefore, sustained economic growth is affected by population growth.

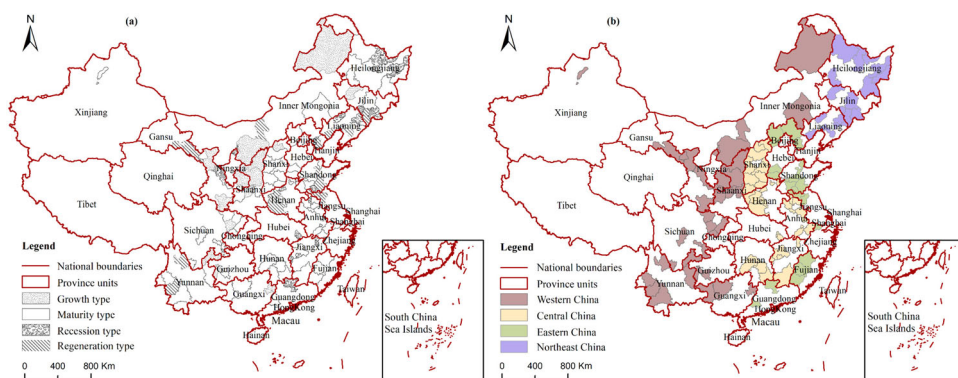
The 'structural dividend', generated when factors of production are transferred from low productivity growth sectors to the high sectors, is an important source of rapid economic growth due to the significant differences in productivity growth rates between sectors (Peneder, 2003). The changes in employment structure brought about by market-oriented reforms have made outstanding contributions to economic growth. However, as the 'demographic dividend' gradually disappears, the benefits of adjusting the employment structure may decrease. He (2018) confirms that market openness positively affects economic growth and employment, and there is a two-way causal relationship between employment and economic growth. There are differences in the development of resource-based cities, but the employment structure must be adjusted to maintain a high economic growth rate. Given this background, this study explores the economic effects of employment structures in heterogeneous regions and provides suggestions for the sustainable development of society and economy in the process of transformation of resource-based cities.

## 4. Materials and methods

### 4.1. Study area

Resource-based cities are cities developed using natural resources that are dominated by resource-based industries. Resource-based cities were defined at the end of 2015,





**Figure 1.** Overview map of the study area.

Note: Drawing review number of base-maps is GS (2019) No.1719 (Supervised by the Ministry of Natural Resources of China).

Source: Drawn by authors.

according to the Plan and related academic research (Yu et al., 2019). There are 116 prefecture-level resource-based cities in China, accounting for approximately 39% of the total number of cities above the prefecture level in China. This study chose 2004 to 2018 as the sample period. The samples were categorised into four types of heterogeneous regions based on the differences in the development stages of resource-based cities. The research objects were 62 mature, 23 recessionary, 16 regenerated and 14 growing resource-based cities, including 115 prefecture-level resource-based cities (Bijie was not included). There are 20, 37, 39, and 19 administrative divisions in the eastern, central, western, and north-eastern regions of China, respectively (Figure 1).

#### 4.2. Variable selection

As an intuitive indicator of economic growth, GDP can reflect the economic development level and comprehensive economic strength of resource-based cities. This study uses real GDP growth rate to represent economic growth ( $Y$ ), the response variable.

Analysis shows that a correlation between economic growth and the proportion of employment in various industries and their increments. Existing research also confirms that employment structure is closely related to economic growth. The flow of labour among industries impacts the output efficiency in each sector, as the speed of economic growth. Therefore, employment structure change ( $\Phi_1$ ,  $\Phi_2$ ,  $\Phi_3$ ), the explanatory variables, can be expressed by the growth rate of labour productivity of each department. Explanatory variables can be obtained by calculating the ratio of value added of output to year-end employment in three industries.

Control variables are as follows: Regardless of whether economic growth is in a stable state, technological progress ( $tec$ ) has a decisive influence on the per capita output growth rate. In this study, the expenditure on scientific undertakings was used. Capital investment ( $inv$ ) is a main production input factor, affecting output. The total investment in fixed assets of the whole society can be selected, and capital investment can be expressed by accounting for fixed capital stock. Educational expenditure ( $edu$ ) is expressed as a proportion of GDP spent on education, with a higher proportion



indicating that the government attaches greater importance to education. Human capital is a key factor influencing economic growth, increasing productivity and promoting employment restructuring by improving managerial and innovation efficiency. This study used the average years of schooling to express population quality (*hum*). Population growth rate (*pop*) is also a source of economic growth and can be expressed as the natural population growth rate. Market openness (*ope*) is the actual utilisation of foreign direct investment which facilitates increased investment and technology introduction, thus affecting economic growth. It is measured by the proportion of actual use of foreign direct investment in each region to GDP.

### 4.3. Methods

#### 4.3.1. Exploratory spatial data analysis

Exploratory Spatial Data Analysis can detect whether the spatial distribution of an element in a region has spatial correlation with its neighbouring regions, and intuitively reflect the distribution model and influence characteristics of the element. Global spatial autocorrelation was used to test whether the employment structure and economic growth of different cities were spatially correlated. It reflects the degree of similarity in the attribute values of spatially contiguous or spatially adjacent regional units and can characterise the spatial distribution of elements within the whole system, usually measured as the Moran's *I* (Anselin, 1988). The calculation formula is expressed as follows.

$$I = \frac{\sum_{i=1}^n \sum_{j \neq i}^n W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{S^2 \sum_{i=1}^n \sum_{j=1}^n W_{ij}} \quad (8)$$

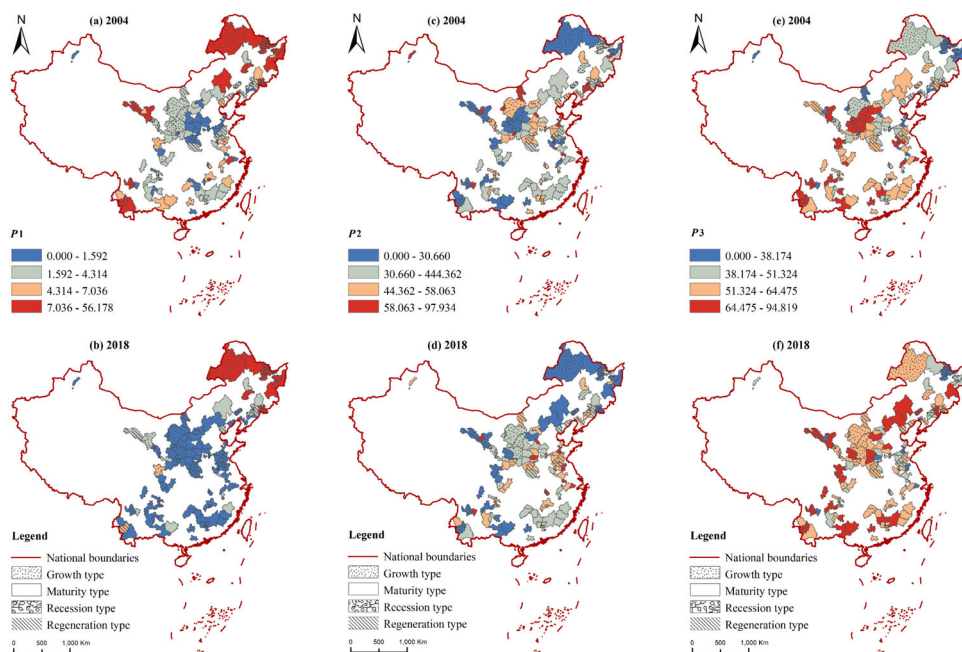
$S^2$  is the variance of the sample,  $X_i$  and  $X_j$  represent the observations of cities  $i$  and  $j$  respectively.  $n$  is the total number of resource-based cities, 115 in total.  $W_{ij}$  represents the weight matrix of queen space based on adjacency relation; it is equal to 1 when region  $i$  and region  $j$  have an edge or a point in common, otherwise, it equals 0. The value range of Moran's *I* is  $-1$  to  $1$ . The closer the absolute of Moran's *I* is to  $1$ , the stronger the spatial correlation is. If the Moran's *I* is equal to  $0$ , it indicates that the regional variables are random in their spatial distribution.

#### 4.3.2. Empirical models

First, the likelihood ratio test (LR test), robust LR test, Lagrange multiplier test (LM test) and robust LM test were carried out. The panel data without spatial interaction effect was estimated to determine whether the spatial model should choose random effect or time fixed effect, a spatial fixed effect, or bidirectional fixed effect. The model was set as follows:

$$Y_{it} = \alpha + \rho WY_{it} + \beta X_{it} + \theta WX_{it} + \varepsilon_{it} \quad (9)$$

The subscript  $i$  represents a resource-based city, and the subscript  $t$  represents a year within the period of study 2004 to 2018;  $\alpha$ ,  $\beta$ , and  $\theta$  are fixed estimated parameters;  $\rho$  represents the spatial autoregressive coefficient or spatial autocorrelation



**Figure 2.** Employment structure of resource-based cities in selected years.

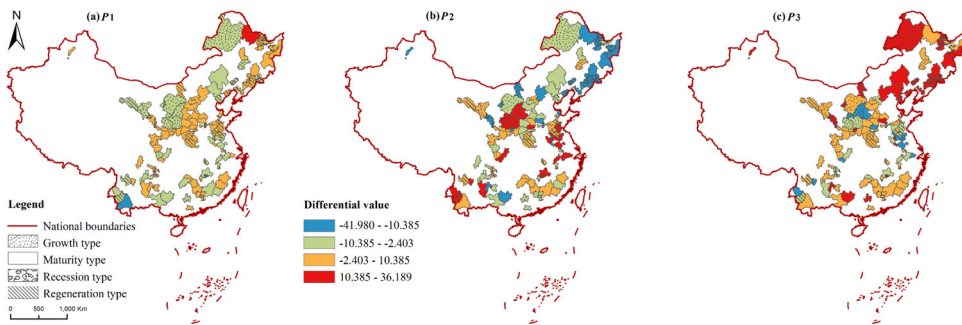
*Note:* Drawing review number of base-maps is GS (2019) No.1719 (Supervised by the Ministry of Natural Resources of China).

*Source:* Drawn by authors.

coefficient; and  $\varepsilon_{it}$  represents the random error term.  $W$  represents the row random space weight matrix of queen contiguity.  $WY_{it}$  represents the endogenous interaction effect between the explanatory variables.  $WX_{it}$  represents the exogenous interaction effect between the explanatory variables.

When selecting the optimal model, the spatial lag model (SAR) or spatial Durbin model (SDM) was selected when  $\theta = 0$ . The spatial error model (SEM) or SDM was selected when  $\theta = \pm\rho\beta$ . The maximum likelihood estimation (ML) method was used to estimate the model parameters. The partial differential estimation method (LeSage & Pace, 2008) can explain the influence of variable changes in the model. Spatial effects can be divided into direct effects (the influence of regional explanatory variables on local regions) and spillover effects (the influence of regional explanatory variables on neighbouring regions). The optimal model is determined, which can estimate the total, direct, and spillover effects of the change in the population's employment structure in the resource-based cities on economic growth. In conclusion, the spatial econometric model can be further set as follows.

$$\begin{aligned}
 Y_{it} &= \alpha + \rho WY_{it} + \beta X_{it} + \theta WX_{it} + \varepsilon_{it} \\
 \beta X_{it} &= \beta_1 \Phi_{1it} + \beta_2 \Phi_{2it} + \beta_3 \Phi_{3it} + \beta_4 tec_{it} + \beta_5 inv_{it} + \beta_6 edu_{it} \\
 &\quad + \beta_7 hum_{it} + \beta_8 pop_{it} + \beta_9 ope_{it} \\
 \theta WX_{it} &= \theta_1 W\Phi_{1it} + \theta_2 W\Phi_{2it} + \theta_3 W\Phi_{3it} + \theta_4 Wtec_{it} + \theta_5 Winv_{it} + \theta_6 Wedu_{it} \\
 &\quad + \theta_7 Whum_{it} + \theta_8 Wpop_{it} + \theta_9 Wope_{it}
 \end{aligned} \tag{10}$$



**Figure 3.** Changes in proportion of employment population from 2004 to 2018.

Note: Drawing review number of base-maps is GS (2019) No.1719 (Supervised by the Ministry of Natural Resources of China).

Source: Drawn by authors.

#### 4.4. Data sources

The data used in this study were obtained from the China Urban Statistical Yearbook, China Fixed Assets Investment Statistical Yearbook, and CEIC Data from 2004 to 2019. Individual missing data were interpolated. To eliminate the influence of inflation and improve the accuracy of the results, the GDP deflator was used to deflate the price-related data based on 2003 report figures. Using the calculation method proposed by Ke (2009) for reference, the fixed capital stock was calculated by using the fixed asset investment price index in the China Statistical Yearbook.

### 5. Results and discussion

#### 5.1. Spatial pattern analysis

Figures 2 and 3 reflect the population employment structure's spatial distribution characteristics in resource-based cities. Based on extreme value and mean value, taking standard deviation as the interval, ArcGIS was used to create classification intervals proportionally and spatial distribution maps.

The characteristics of time evolution postulate that from 2004 to 2018, the proportion of employed population in the primary industry ( $P_1$ ) of resource-based cities decreased yearly falling by approximately 41% over the 15 years. The proportion of employed population in the secondary industry ( $P_2$ ) has remained at around 50%. The proportion of employed population in the tertiary industry ( $P_3$ ) fluctuated and increased by approximately 8%. The concentrated distribution areas of resource-based cities have a relatively high employment population. Primary industry is in Northeast China. Secondary industry is situated near the Yellow Sea and the Bohai Sea, which are mainly regeneration and recession types. Tertiary industry is in the central and western regions of China (Figure 2).

From the perspective of spatial heterogeneity,  $P_1$  in a few maturity-type cities in Northeast China and West China has significantly changed.  $P_2$  in recession-type cities in Northeast and Western China has been dramatically reduced.  $P_2$  in eastern, central, and western growth-type cities has increased, and  $P_2$  in the regeneration-type cities around the Yellow Sea was still relatively high by 2018.  $P_3$  in recession-type cities

**Table 1.** Descriptive statistics.

	Mean	Std.Dev	Median	Min	Max
Y	11.092	4.928	11.600	-19.380	37.690
$\Phi_1$	26.755	108.301	10.792	-970.344	813.070
$\Phi_2$	2.327	3.642	2.026	-23.262	50.840
$\Phi_3$	1.920	2.079	1.564	-15.781	20.536
tec	0.002	0.002	0.001	0.000	0.063
inv	0.001	0.002	0.000	0.000	0.023
edu	0.033	0.018	0.029	0.002	0.142
hum	8.503	0.550	8.429	6.779	10.718
pop	5.482	4.928	5.300	-16.270	39.180
ope	0.014	0.016	0.009	0.000	0.118

Source: Authors' calculations.

in Northeast China remained at a low level during the study period. However,  $P_3$  of regeneration-type cities in the eastern region and of growth-type cities in the western region decreased.  $P_3$  of growth-type cities in eastern Inner Mongolia and most cities in Northeast China increased significantly (Figure 3).

## 5.2. Descriptive statistics and correlation analysis

Table 1 shows the summary statistics for the variables of the spatial econometrics model. Among the core explanatory variables, the standard deviation of labour productivity growth in the primary sector ( $\Phi_1$ ) was the largest due to the considerable variation in  $P_1$  over the study period. The growth rate of labour productivity in the secondary sector ( $\Phi_2$ ) was also relatively large. Using the county-level database from 1997 to 2010, Cheong and Wu (2014) proved that the root of the difference in regional economic growth rate in China was the difference in the degree of development in the secondary industry among regions. The growth rate of labour productivity in the tertiary sector ( $\Phi_3$ ) was relatively low, which indicated that the high-end of the tertiary industry chain of resource-based cities had a relatively low proportion. Among the control variables, the mean values of population quality and natural population growth rate are 8.43 and 5.30, respectively, which indicated that the quality of population in resource-based cities had been improving and the total population had been increasing.

As the prerequisite for constructing a spatial panel model, the core variables must satisfy the spatial correlation. This study used Moran's  $I$  to determine whether the economic growth and employment structure variables of resource-based cities had spatial autocorrelation characteristics (Table 2). The Moran's  $I$  of GDP from 2004 to 2018 was in the range of 0.18 to 0.60, and passed the significance test at 5%. This suggested that both economic growth and employment structure had a significant spatial correlation. Spatial externality is an important factor affecting economic growth and should be incorporated into spatial econometric models with its spatial lag terms.

## 5.3. Results of resource-based cities

The effect of population employment structure change on regional economic growth in resource-based cities from 2004 to 2018 was estimated using MATLAB. First, the

**Table 2.** Spatial correlation tests.

Year	$\gamma$		$\Phi_1$		$\Phi_2$		$\Phi_3$	
	Moran's $I$	$Z(I)$	Moran's $I$	$Z(I)$	Moran's $I$	$Z(I)$	Moran's $I$	$Z(I)$
2018	0.249***	2.783	0.162***	3.134	0.169**	1.936	0.297***	3.310
2017	0.464***	5.145	0.060*	1.077	0.125*	1.544	0.154**	1.795
2016	0.597***	6.749	0.064*	0.967	0.370***	4.267	0.369***	4.286
2015	0.330***	3.690	-0.002	0.345	0.171**	1.984	0.070*	1.274
2014	0.582***	6.657	-0.068***	-2.523	0.530***	5.905	0.380***	4.316
2013	0.221***	2.534	0.009***	2.742	0.194**	2.236	0.138**	1.802
2012	0.298***	3.409	0.008**	2.947	0.136*	1.623	0.453***	5.011
2011	0.285***	3.329	0.052*	1.144	0.023	0.530	0.434***	4.828
2010	0.368***	4.163	0.110*	1.399	0.093*	1.284	0.441***	4.910
2009	0.488***	5.440	0.121*	1.613	0.143**	1.663	0.550***	6.098
2008	0.280***	3.136	0.057*	1.286	0.303***	3.722	0.196**	2.251
2007	0.193**	2.203	0.103*	1.354	0.172***	2.166	0.102*	1.332
2006	0.311***	3.449	0.098*	1.379	0.128*	1.656	0.132*	1.609
2005	0.277***	3.206	0.126*	1.615	0.181**	2.176	0.247***	2.913
2004	0.182**	2.139	0.231***	3.570	0.229***	2.578	0.232***	2.648

Note: The numbers in parentheses are t-statistics. Asterisks means the figure is statistically significant. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations.

Hausman test was set, and the estimated value of the test result was 50.25 ( $p < 0.01$ ), which indicated that the fixed effect model could be chosen. The non-spatial panel model test showed that the two-way fixed effect's Log-L value was the largest (Table 3). It passed the (robust) LM test and the LR test of spatial (or temporal) fixed effects at a significance level of 1%. Consequently, SAR or SDM with two-way fixed effects should be selected for estimation, based on the test results in Table 4.

Table 4 shows that the  $\rho$  values of SAR and SDM models all pass the test at the 1% significance level. The degree of fit of the parameters was high—  $R^2$  values were all greater than 0.6, and all Log-L values were small. The spatial lagged LR test and Wald test rejected the original hypothesis at the significance level of 1%, which showed that SDM could not be simplified as SAR. From the results of parameter estimation, SDM with the two-way fixed effect was the optimal model. Most of the explanatory variables in SDM were not at the zero-significance level after the spatial lag term was added, which showed that these explanatory variables have significant spatial effects on resource-based cities' economic growth. It can be determined that SDM had a systematic deviation in the estimation of spillover effects. Table 5 decomposes each explanatory variable to determine the influence coefficients of its direct effects and spillover effects.

The coefficient of  $\Phi_2$  in SDM was 0.21, which was significantly positive. This shows that accelerated labour productivity in the secondary industry promotes economic growth. Resource-based cities are small and medium-sized cities. The key to improving economic growth in small cities lies in developing industries according to local conditions rather than productive services (Deng & Zhang, 2020). Therefore, increasing labour productivity in the secondary industry positively impacts economic growth. Furthermore, *edu* and *tec* played an irreplaceable role in promoting the economic growth of resource-based cities. Moreover, *pop* had no significant impact on the economic growth of resource-based cities. This conclusion is consistent with Gregory (1980); that is, there is no evidence that population growth hinders economic growth.

**Table 3.** Results of non-spatial panel model test.

Effect	OLS	Total					Growth type Two-way fixed	Maturity type Two-way fixed	Recession type Two-way fixed	Regeneration type Two-way fixed
		Spatial-fixed	Time-fixed	Two-way fixed	Two-way fixed	Two-way fixed				
Log-L	-4950.000	-4750.000	-4540.000	-4360.000	-518.018	-2160.000	-920.814	-646.422		
LMLAG	441.021***	444.657***	155.203***	150.740***	3.843**	32.188***	22.129***	8.645***		
R-LMLAG	95.691***	200.248***	44.404***	37.409***	3.781*	11.151***	6.557**	4.236**		
LMERR	361.760***	279.196***	126.156***	125.673***	10.143***	26.272***	16.577***	5.064**		
R-LMERR	16.391***	34.787***	15.357***	12.342***	10.080***	5.235**	1.005	0.655		

Note: The numbers in parentheses are t-statistics. Asterisks means the figure is statistically significant. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.  
Source: Authors' calculations.

**Table 4.** Estimation result of the spatial econometric model with spatial and time fixed effect.

Variables	Total			Growth	Maturity	Recession	Regeneration
	OLS	SAR	SDM	type SDM	type SDM	type SDM	type SDM
$\Phi_1$	0.001 (0.391)	0.001 (0.245)	0.001 (0.040)	0.004 (1.483)	-0.001 (-0.271)	0.001 (0.696)	-0.005* (-1.534)
$\Phi_2$	0.258*** (8.883)	0.225*** (7.851)	0.214*** (7.730)	0.104*** (2.281)	0.251*** (6.138)	0.963*** (6.009)	0.506*** (3.694)
$\Phi_3$	0.036 (0.670)	0.015 (0.280)	-0.003 (-0.171)	0.011 (0.059)	0.071 (1.171)	0.058 (0.291)	0.323** (1.999)
<i>tec</i>	125.473*** (3.111)	106.238*** (2.653)	96.028** (2.469)	55.767 (1.041)	137.574** (2.473)	476.285* (1.852)	-451.220 (-1.445)
<i>inv</i>	-16.589 (-0.223)	-8.681 (-0.118)	-3.930 (-0.049)	90.548 (0.362)	-89.425 (-0.975)	-90.406 (-0.385)	122.730 (0.764)
<i>edu</i>	44.188*** (3.222)	33.065** (2.519)	27.496** (2.178)	28.464 (1.013)	15.406 (1.006)	15.768 (0.373)	137.949*** (2.844)
<i>hum</i>	0.036 (0.123)	0.002 (0.006)	0.085 (0.296)	7.231*** (6.750)	-0.684** (-2.142)	0.020 (0.024)	-0.731 (-0.689)
<i>pop</i>	0.084*** (3.628)	0.068*** (2.885)	0.036 (1.637)	0.058 (1.226)	0.031 (1.077)	0.132* (1.789)	-0.043 (-0.658)
<i>ope</i>	15.074** (2.013)	14.868** (2.012)	22.759*** (3.024)	61.347* (1.652)	17.922* (2.016)	19.740 (0.942)	14.607 (0.782)
$W^*\Phi_1$			0.002* (1.685)	0.005 (0.368)	0.001 (0.216)	-0.062 (-1.122)	-0.005 (-0.750)
$W^*\Phi_2$			0.152*** (3.714)	0.155 (1.274)	0.137** (2.171)	0.678** (2.767)	0.273** (2.032)
$W^*\Phi_3$			0.192** (2.678)	0.260 (0.771)	0.156 (1.312)	-0.364 (-0.938)	0.273 (1.100)
$W^*tec$			76.192 (1.572)	-81.328 (-1.339)	214.222** (2.228)	886.655 (0.962)	866.778 (1.254)
$W^*inv$			-58.135 (2.649)	-31.510 (-0.090)	-42.305 (-0.561)	356.534 (0.797)	-2.550 (-0.011)
$W^*edu$			45.891*** (2.649)	-111.780** (-2.271)	40.382** (2.194)	-13.609 (-0.209)	-120.814 (-1.389)
$W^*hum$			-0.005 (-0.031)	5.284*** (3.150)	0.290 (0.663)	-5.297*** (-3.476)	-2.748 (-1.611)
$W^*pop$			0.085*** (2.930)	0.104 (1.121)	-0.016 (-0.431)	0.293** (2.119)	0.068 (0.840)
$W^*ope$			-23.460** (-2.279)	39.432 (0.727)	-34.650*** (-2.723)	21.987 (0.362)	6.419 (0.277)
$\rho$		0.260*** (11.407)	0.227*** (9.641)	-0.236*** (-3.064)	0.131*** (3.896)	-0.236*** (-3.630)	-0.236*** (-3.657)
R <sup>2</sup>	0.080	0.659	0.664	0.748	0.672	0.646	0.660

Note: The numbers in parentheses are t-statistics. Asterisks means the figure is statistically significant. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations.

Employment structure with the spatial lag term was significantly different from 0. After decomposition, the spatial effect on regional economic growth was also significantly positive. Namely,  $\Phi_2$  had a significant positive impact on both the local and surrounding cities' economic growth. The decline in  $\Phi_1$  and  $\Phi_3$  inhibited the economic growth of surrounding resource-based cities, which had been caused by technology spillovers, investment in education and optimisation of employment structures.

#### 5.4. Result of heterogeneous regions

The influence coefficient of  $\Phi_2$  in growth-type cities was 0.10, the direct effect coefficient was 0.09, both of which passed the significance test. The results show that increasing  $\Phi_2$  can promote local economic growth.  $\Phi_1$  and  $\Phi_3$  had no significant



**Table 5.** Spatial effect decomposition of SDM based on panel data.

	Variables	Direct	Indirect	Total
Total	$\Phi_1$	0.001 (0.317)	0.002* (1.675)	0.003 (1.537)
	$\Phi_2$	0.235*** (8.344)	0.238*** (5.203)	0.473*** (8.299)
	$\Phi_3$	0.016 (0.309)	0.226*** (2.646)	0.242** (2.334)
	<i>tec</i>	105.735*** (2.706)	117.949** (2.062)	223.684*** (2.900)
	<i>edu</i>	32.274** (2.481)	61.741*** (2.970)	94.015*** (3.489)
	<i>pop</i>	0.046** (1.992)	0.112*** (3.312)	0.156*** (3.806)
	<i>ope</i>	21.259*** (2.918)	-22.180* (-1.862)	-0.921 (-0.068)
Growth type	<i>edu</i>	36.881 (1.295)	-105.636** (-2.480)	-68.755 (-1.334)
	<i>hum</i>	6.950*** (6.677)	3.207** (2.311)	10.157*** (6.072)
Maturity type	$\Phi_2$	0.260*** (6.115)	0.187*** (2.737)	0.446*** (5.456)
	<i>tec</i>	149.127*** (2.767)	251.319** (2.392)	400.446*** (3.301)
	<i>edu</i>	17.485 (1.148)	46.864** (2.308)	64.349** (2.475)
Recession type	<i>ope</i>	16.358* (1.798)	-35.698** (-2.558)	-19.341 (-1.111)
	$\Phi_2$	0.9299*** (5.873)	0.397* (1.795)	1.327*** (5.954)
	<i>hum</i>	0.399 (0.361)	-4.688*** (-3.299)	-4.289*** (-3.112)
Regeneration type	<i>pop</i>	0.117 (1.477)	0.220* (1.758)	0.336*** (3.141)
	<i>edu</i>	153.188*** (3.113)	-142.627* (-1.860)	10.561 (0.128)

Note: The numbers in parentheses are t-statistics. Asterisks means the figure is statistically significant. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors' calculations.

impact on the economic growth of growth-type cities. Obviously, significant problems exist, such as the long distance from provincial capitals, unbalanced economic development, and irregular order of resource development. In the process of development, the population can be transferred to employment in secondary and tertiary industries to promote economic transformation and upgrading. This type of urban natural resource reserve can be exploited for a long time, so the government can undertake orderly planning, raise the threshold, and develop rationally. Moreover, it accelerates the cultivation of the resource industry chain (Sun & Zheng, 2019) and continues to absorb the population and transfer it to the secondary industry for employment.

The influence coefficient of  $\Phi_2$  in maturity-type cities was 0.25, the direct effect coefficient was 0.26, and the indirect influence coefficient was 0.19, both of which were significantly positive. This shows that increasing  $\Phi_2$  has a positive effect on the economic growth of a city and its surrounding cities.  $\Phi_1$  and  $\Phi_3$  had no significant influence on economic growth. Maturity-type cities can stably develop more intense resources. Mining, transportation, and processing systems are also relatively mature. The proportion of the employed population in extractive industries is still increasing (Yu et al., 2019). Therefore, a higher proportion of the secondary industry's employed population is beneficial for regional economic growth. However, the problems of environmental governance are prominent, and there are many contradictions in the distribution of various interests, so the speed of transformation and development is relatively slow. In transformation and development, maturity-type cities should lengthen the industrial chain, promote development of the urban economy, improve the utilisation of resources by combining new technologies, cultivating enterprises with deep processing of resources, and build new brands made in China to promote sustained economic growth.

The influence coefficient of  $\Phi_2$  in recession-type cities was 0.96, the direct effect coefficient was 0.93, and the indirect influence coefficient was 0.40, both of which were significantly positive. Increasing  $\Phi_2$  and vigorously developing alternative

**Table 6.** Estimation results of robustness tests.

Variables	Total			Growth type SDM	Maturity type SDM	Recession type SDM	Regeneration type SDM
	OLS	SAR	SDM				
$\Phi_1$	0.001 (0.391)	-0.001 (-0.116)	0.001 (0.038)	0.004 (1.136)	-0.001 (-0.077)	0.001 (0.626)	-0.004* (-1.176)
$\Phi_2$	0.257*** (8.883)	0.241*** (8.333)	0.228*** (8.217)	0.125*** (2.735)	0.251*** (6.380)	1.025*** (6.514)	0.558*** (4.429)
$\Phi_3$	0.036 (0.670)	0.015 (0.276)	-0.013 (-0.251)	-0.126 (-0.679)	0.051 (0.837)	0.213 (1.115)	0.285* (1.849)
$W^*\Phi_1$			0.018** (2.054)	0.006 (0.692)	0.019** (2.066)	0.008 (0.672)	0.005 (0.623)
$W^*\Phi_2$			0.214* (0.651)	-0.009 (-0.081)	0.572** (2.148)	3.086*** (3.379)	0.482* (1.771)
$W^*\Phi_3$			-0.631* (-0.986)	-0.645 (-1.537)	0.086 (0.133)	0.398 (0.330)	-0.085 (-0.209)
$\rho$		0.798*** (23.204)	0.423*** (5.072)	-0.231* (-1.725)	0.290*** (2.945)	-0.275* (-1.845)	-0.324*** (-2.227)
$R^2$	0.080	0.653	0.663	0.728	0.687	0.713	0.667

Note. The numbers in parentheses are t-statistics. Asterisks means the figure is statistically significant. \*, \*\*, and \*\*\*denote significance at the 10%, 5%, and 1% levels, respectively.

Source. Authors' calculations.

industries can accelerate economic transformation and speed of development. The rate of technological progress in recession-type cities was lower than the rate of resource depletion. The original pillar industries still contribute a greater proportion of economic growth, while upgrading  $\Phi_2$  will increase the possibility of technology spillovers, which is beneficial to the economic development of surrounding cities. Affected by the decline of resource development, the economic development of recession-type cities was sluggish, and hidden unemployment was widespread. Recession-type cities have a high industrial concentration, and strengthening the endogenous power of urban development could reduce its dependence on resources. And raising the natural population growth rate, promoting the quality of the employed population to match productivity could solve historical problems such as the reemployment of miners, which lead to green economy development.

The impact coefficients for the change in employment structure in regeneration-type cities were -0.01, 0.51 and 0.32, with the spatial effects mainly direct, which shows that transferring the employed population in the primary industry to the secondary and tertiary industries, and upgrading  $\Phi_2$  and  $\Phi_3$  can promote economic growth. Most resource exploitation activities in renewable cities have stopped, and their dependence on resource-based economies is not high. The emission intensity of water and gas is also low, and the economy and society gradually develop. Therefore, increasing  $\Phi_2$  leads to a series of economic, social, and ecological problems caused by resource exploitation which still negatively impact economic growth. Improving the efficiency of tertiary output, especially high-tech industries, can effectively solve these problems. Săvoiu et al. (2015) confirm that the service industry is an important factor in economic growth, and its role in the economy is increasing. Compared with the other three types of cities, regeneration-type cities have an enormous comprehensive economic scale. Transformation and development should promote urban functions, increase investment in education to enhance development, and establish a long-term mechanism for sustainable development.

### 5.5. Robustness test

To test the robustness of the economic growth effect of employment structure adjustment, the results were retested by constructing a spatial weight matrix of geographical distance instead of the spatial weight matrix of adjacency relation (Table 6). The most significant difference between the robustness test results and the previous results is that the coefficients of the variables, spatial spillover coefficients and significance have been somewhat increased or decreased. However, the estimation results of the core variables are basically consistent with the above conclusions. This result shows that the effect of changes in the employment structure on economic growth is reliable and robust.

## 6. Conclusions

Following the concept of sustainable development, the Chinese government promulgated the Plan to prevent resource-based cities from falling into the 'resource curse'. In transformation, resource-based cities strive to develop a green economy and actively promote population transfer to non-agricultural industries. In this context, this study analysed the relationship between employment structure adjustment and economic growth in 115 prefecture-level resource-based cities in China from 2004 to 2018. The results show differences in the economic effects of employment structure adjustment in heterogeneous regions. Overall, increasing labour productivity in the secondary industry and building an industrial system according to local advantages are the top priorities in developing the economy of resource-based cities. Moreover, it is necessary to improve labour productivity in the tertiary industry, improve the comprehensive service function of cities, and promote the return of high-tech talent. Simultaneously, increasing investment in education and technology and expanding market openness can significantly boost the sustained economic growth of resource-based cities. From the perspective of regional heterogeneity, promoting the proportion of employed people in the three industries in resource-based cities to be reasonable is an appropriate strategy. Increasing labour productivity in the secondary industry in all types, not only the tertiary industry, and reducing the labour input in the primary in regeneration-type, is conducive to the rational development and utilisation of natural resources in resource-based cities.

This study confirms differences in the impact of heterogeneous regional employment structure adjustments on economic growth. As in previous studies, this study inevitably has several limitations. Future research can further explore the non-linear factors of the adjustment of employment structure to economic growth or the relationship between the adjustment of employment structure and the rate of economic growth. Second, whether the research results of this study apply to resource-based cities at the same developmental stage in other regions needs further discussion. In future research, international samples from South Africa and the Middle East may expand the current research.

## Notes

Average years of schooling = (number of primary school students  $\times 6$  + number of ordinary secondary school students  $\times 10.5$  + number of higher school students  $\times 16$ ) / total number of students enrolled.

$P_1$ ,  $P_2$ , and  $P_3$  were calculated by the ratio of employed population in the primary, secondary, and tertiary sector industries to the total employed population.

In the two-way fixed effects test results, the estimated value of the LM test for SAR was 150.74, and for SEM was 125.67. The estimated value of the robust LM test for SAR was 37.41, and for SEM was 12.34.

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