Study on the Coupling Mechanism of Regional Economy and Regional Population Mobility in Less Developed Regions Based on AHP-CRITIC Coupling Perspective

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Abstract. The purpose of this paper is to analyze the coupling mechanism between regional economy and regional population mobility in less developed regions. This paper selects Gansu Province as the research object of this paper for less developed regions and measures the level of synergy between regional economy and regional population mobility in Gansu Province of China by establishing a composite system synergy model of regional economy and regional population mobility, establishing indicator weights based on AHP (Analytic Hierarchy Process)-CRITIC (Criteria Importance Though Intercrieria Correlation) coupling weights. The composite system synergy of regional economy and regional population mobility in Gansu Province shows an alternating trend of increase and decrease from 2013 to 2021, which is generally at a low level of synergy. This paper introduces the synergy model for the study of regional economy and regional population mobility mechanism, and in the measurement of system orderliness, high-quality indicators that can fully reflect the level of regional economy and regional population mobility are selected, and the AHP-CRITIC coupled weighting method is used for the calculation of indicator weights, so as to improve the rationality of the weights, and this research method provides less developed regions research on regional economy and regional population mobility provides a reference. Therefore, Gansu Province and other less developed regions can promote the synergistic development of regional population mobility and regional economy by establishing sound supporting measures for intra-regional population mobility, optimizing the population structure, enhancing the gathering capacity of the working population, and encouraging people to return to their hometowns to start their own businesses.

Keywords: AHP-CRITIC; Synergy Model; Less Developed Regions; Economy; Population Mobility.

1. Introduction

Human resources are an important factor affecting the development of regional affairs, so population movement and regional economy are closely linked. Generally speaking, the more developed the regional economy is, the more it can attract population inflow, which in turn promotes the economic development of the region. However, there are now few studies on coupling mechanism of regional economy and regional population mobility.

By constructing a Pudong panel econometric model and a spatial econometric model, He[1] showed that population mobility and environmental regulations play a direct role in enhancing high-quality economic development in terms of regional heterogeneity, and there are synergistic effects and strong spatial spillover effects, which are significantly stronger for cities in the western region than in the eastern and central regions. He[2] also constructed a fixed-effect model and a mediating-effect model, on the basis of elucidating the theoretical mechanism of population mobility affecting economic growth, found that population mobility can significantly affect the economic development of inflowing regions, and the promotion effect is mainly realized through improving labor productivity, promoting industrial structure upgrading, enhancing consumption capacity and increasing social investment channels Using a panel fixed-effects model, Zhang[3] investigated the relationship between labor mobility and economic growth under Chinese-style fiscal decentralization from three perspectives: linear, nonlinear and spatial spillover effects, and found that both labor mobility and fiscal decentralization promoted economic growth, and this effect had a significant positive spatial spillover effect. Through literature review and theoretical elaboration, Yu[4] tested the theoretical hypothesis of population mobility and economic growth, and the results showed that population mobility promoted economic growth in net population inflow areas and economic growth in net population outflow areas. Based on the Cobb-Douglas production function, Zhang[5] used urban panel data on the basis of the Cobb-Douglas production function to construct a theoretical model of the nonlinear effect of mobile population on economic development and concluded that developed regions such as "Beijing, Shanghai, and Guangzhou" gradually entered the stage of population return, while most of the remaining regions are still in the positive correlation between mobile population and economic development, and an inverted U-shaped relationship between mobile population and economic development. Gong[6] built a three-period OLG model based on the OLG model constructed by Blanchard and Fischer, and introduced the "combined account" pension security system in China, considering the cross-regional migration and mobility of young people and the provision of intergenerational care for the elderly. Chen[7] constructed a multi-regional population location choice model based on the new spatial economics theory, analyzed the influencing factors and intrinsic mechanisms of population mobility decisions in Northwest China, and empirically concluded that the level of economic development in the inflowing areas, among others, significantly drives the extraterritorial outflow of the population in Northwest China.

Although the existing results are relatively abundant, their evaluation index systems lack data’s novelty and high-quality development indicators, and mostly only use a single assignment method to construct a model. This paper enriches the existing evaluation index system by selecting indicators such as per capita GDP and per capita disposable income that can fully reflect the quality of regional economic development, as well as indicators related to population mobility such as the area of completed construction of guaranteed housing, the ratio of the total railroad and highway mileage to the total population, etc., constructing a subsystem with the regional economy of less developed regions and regional population mobility as the research object, and building a synergistic model of the subsystem, and then use the latest data of National Bureau of Statistics from 2013 to 2021 with the method of coupling AHP and CRITIC to calculate the indicator weights. In essence, the subjective and objective assignment method is integrated to increase the reliability and feasibility of the evaluation results. Finally, the model is applied to the measurement of the level of synergistic development between regional economy and regional population mobility in Gansu Province for empirical analysis. This paper provides a reference for the research and development of the coupling mechanism of regional economy and population mobility in less developed regions, and to a certain extent, promotes the exploration of effective mechanisms for the synergistic development of population mobility and economic growth in Gansu Province and less developed regions, in order to help optimize the spatial allocation of population resources in Gansu Province and even in less developed regions, and promote high-quality economic development in less developed regions.

2. Construction of two subsystems

2.1 Construction of regional economic subsystem

Regional economy is a part of national economy, which is also comprehensive and regional and refers to the economy of resource utilization and allocation in a certain area or space[8]. It is influenced by various factors such as geographical environment, history and culture, economy, and cultural beliefs. The factors that influence are the basic technical conditions, socio-economic level, policies of the whole region, as well as climatic conditions, history, the degree of improvement of transportation construction and infrastructure, cultural construction, the level of quality education, etc.[9]. From the perspective of the local economic system, the factors affecting the regional economy include financial inputs, the strategic orientation of economic development, ownership structure, economic efficiency, and accumulation of human capital[3]; from a global perspective, regional economic disparities are the result of the combined effect of multiple factors such as production factor inputs, geographic location, historical factors, policy orientation, economic integration, and globalization; with a dynamic perspective, technological innovation, institutional change, and capital accumulation have a significant role in regional economies.

2.2 Construction of regional population mobility subsystem

Economic, geographical, and social factors are important factors influencing population movement.[10] Higher levels of economic development and larger population size are more attractive to foreign populations.[11] Other factors that influence population movement are the population density of the city, the share of secondary and tertiary industries in GDP, the government's per capita expenditure on education and science and technology, whether the city is open to high-speed rail, the average slope, the average precipitation, and PM2.5 concentration[11], the demand for labor, and the system. The regional population flow shows economic-oriented characteristics in terms of spatial attributes such as macro flow and geographical characteristics; in macro terms, it mainly manifests itself in the flow from rural areas to towns or cities, with large cities dominating; in geographical terms, it manifests itself in the flow from less developed western regions to the east where the development level is more advantageous; in terms of time, the population flow stays in cities for a longer period and the economic and social ties with the outflow areas gradually become weaker.

In summary, the regional economic and regional population mobility subsystems constructed in this paper are shown in Table 1 below:

Table 1 regional economy and population mobility subsystems

System	Indicator	Indicator Unit	Correlation	Reference
System of regional economy X1	GDP per capita X11	Yuan	+	[13]
	Disposable income per capita X12	Yuan	+	[12]
	GDP of the local area X13	100 million yuan	+	[13]、[14]
	Secondary industry output value X14	100 million yuan	+	[11]
	Tertiary industry output X15	100 million yuan	+	[12]、[13]
	Local revenue X16	100 million yuan	+	[13]
	Local financial expenditures on culture, sports, broadcasting, education, science, health, etc. X17	100 million yuan	+	[13]
System of population mobility Y1	Year-end resident populationY11	10,000 people	+	[14]
	Completed construction area of guaranteed housing Y12	10,000 square meters	+	[15]
	Ratio of total rail and road mileage to total population Y13	kilometer/10,000 people	+	[16]
	Natural population growth rate Y14	%	-	[16]

3. Construction of collaborative model of composite system

3.1 Subsystem order degree model

3.1.1 Calculation of index order degree

Regional economy and regional population flows are defined as composite system $X=\{X_1,X_2\}$,where X_1 represents the regional population flows subsystem, X_2 represents the regional economic subsystem. The evolution of the subsystem is affected by the order parameter X_{ij} ={ X_{i1} , X_{i2} ,..., X_{in} }, $j \in (1,2,\cdots,n)$, $n \geq 1$, $i \in (1,2)$. According to the synergy theory, the calculation formula of order parameter is as follows:

$$U_{ij}=\begin{cases}\dfrac{X_{ij}-\alpha_{ij}}{\beta_{ij}-\alpha_{ij}}, j \in (1,2,\cdots,p) \\ \dfrac{\beta_{ij}-X_{ij}}{\beta_{ij}-\alpha_{ij}}, j \in (p+1,p+2,\cdots,m)\end{cases} \tag{1}$$

Where α_{ij} and β_{ij} represent the upper and lower limits of the parameters of the stable system, respectively. When $j \in (1,2,\cdots,p)$, with the increase of the order parameter X_{ij} , the order degree of the subsystem increases, and X_{ij} is a positive indicator. When $j \in (p+1, p+2,\cdots, m)$, as the order parameter X_{ij} increases, the order degree of the subsystem decreases, and X_{ij} is a negative indicator[17]. From the formula (1), the index order degree $U_i(X_{ij}) \in [0,1]$, and the greater the value of $U_i(X_{ij})$ is, the greater the contribution of order parameters to the subsystem is. Conversely, the smaller.

3.1.2 Calculation of system order degree

In this paper, the weight coefficient of the order parameter W_{ij} is determined based on the calculation method of AHP-CRITIC, indicating the importance of the order parameter in the orderly operation of the subsystem[18].Then the calculation formula of subsystem order degree is as follows :

$$U_i(X_i)=\sum_{j=1}^{n} W_{ij} U_i(X_{ij}), \quad 0 \leq W_{ij} \leq 1, \sum_{j=1}^{n} W_{ij}=1 \tag{2}$$

From the formula (2), it can be seen that $U_i(X_i) \in [0,1]$,and the greater the value of $U_i(X_i)$ is, the higher the degree of order of subsystems is. On the contrary, the lower.

3.2 collaborative model of composite system

The synergy degree of the composite system of regional economy and regional population flows reflects the comprehensive synergy degree of the two systems in the operation process. Assuming that the order degree of the two subsystems in t-1 period is $U_1^{t-1}(X_1)$ and $U_2^{t-1}(X_2)$ respectively, with the continuous evolution and development of the subsystems, the order degree of the two subsystems in t period is $U_1^t(X_1)$ and $U_1^t(X_1)$ respectively[19].The calculation method of the synergy degree of the composite system of regional economy and regional population flows is:

$$U_t = sig(\bullet)\sqrt{\left|U_1^t(X_1)\text{-}U_1^{t\text{-}1}(X_1)\right|}\sqrt{\left|U_2^t(X_2)\text{-}U_2^{t\text{-}1}(X_2)\right|} \tag{3}$$

$$sig(\bullet)=\begin{cases}1, & U_1^t(X_1)\text{-}U_1^{t\text{-}1}(X_1)\geq 0,\ U_2^t(X_2)\text{-}U_2^{t\text{-}1}(X_2)\geq 0\\ \text{-}1, & else\end{cases} \tag{4}$$

$U_i^t(X_i)\text{-}U_i^{t\text{-}1}(X_i)$ is the difference of the order degree of subsystem X_i in the period of [t-1, t]. If the order degree of the two subsystems increases in the period of [t-1,t], that is, the two systems are in an orderly development state in the period of [t-1,t], then $sig(\bullet)$=1, and U_t is a positive value, indicating that the composite system of regional economy and regional population flow is in a state of coordinated development. If the order degree of the two subsystems increases and decreases during the [t-1, t] period, then $sig(\bullet)$=-1, which indicates that the composite system of regional economy and regional population flows is in a lower level of coordinated development.

Usually, the synergy degree of the composite system $U_t \in [-1,1]$, and when U_t tends to 1, it shows that the synergy degree of regional economy and regional population flows is higher, regional economy and regional population flows are in a state of positive coordinated development; when U_t tends to − 1, it indicates the synergy degree between regional economy and regional population flows is lower, regional economy and regional population flows are in a state of disorder development.

4. AHP-CRITIC method

AHP (Analytic Hierarchy Process) is a method which is widely used to determine the weight. Its main drawback is that the weight is determined with strong subjectivity. CRITIC (Criteria Importance Though Intercrieria Correlation) is a method to calculate the objective weight based on the comprehensive measurement of contrast strength and index conflict. Its main drawback is that the calculation of weight is too objective, and the actual importance of the index is ignored to some extent.

Therefore, this paper uses the method of combining AHP and CRITIC to determine the coupling weight, so as to improve the rationality of the index evaluation system.

4.1 AHP method

AHP (Analytic Hierarchy Process) [20] was proposed by Professor T. L. Saaty, American operational researcher, in the 1970s. AHP (Analytic Hierarchy Process) converts complex problems into orderly hierarchical problems. According to the subordinate relationship between factors, factors are classified and combined into an orderly hierarchical structure model, which makes the research problem more organized. The subjective judgment of decision makers and the objective judgment of experts are combined and quantify the to obtain the weight of factors. This method combines qualitative analysis with quantitative analysis, regards the problem as a whole, and decomposes the related factors into different levels. It has been widely used to solve the target problem with clear hierarchy. The specific steps are as follows:

Step1. Construction of index evaluation hierarchy model. Around the research questions, establish a hierarchical index evaluation system.

Step2. Determine the scale. Using Saaty ' s " nine-level scaling method " to determine the relative importance between factors, make a pairwise comparison to build a judgment matrix $A=(B_{ij})_{n\times n}$.

Step3. Calculate the weight. The judgment matrix A is normalized by column by arithmetic average method or geometric average method, and then the corresponding weights of each factor are calculated. Assuming that $w=(w_1,w_2,\cdots,w_n)^T$ is the weight vector corresponding to each index weight, w satisfies $Aw=\lambda_{\max}w$, then the maximum eigenvalue $\lambda_{\max}$ is calculated. Step4.

Consistency test. (1) Calculate the consistency index $CI = \frac{\lambda_{\max} - n}{n - 1}$, where n is the rank of the judgment matrix; (2) The consistency test RI value was obtained by checking the table; (3) Calculate the consistency ratio $CR = \frac{CI}{RI}$, if CR < 0.1, the consistency test passed; otherwise, the judgment matrix needs to be adjusted.

4.2 CRITIC method

CRITIC (Criteria Importance Though Intercrieria Correlation) [21] is an objective weight calculation method proposed by Diakoulaki. It is based on data volatility (intra-index contrast intensity) and correlation (inter-index conflict) to determine the index weight. It is completely out of the objective attribute of the data itself and does not depend on people' s subjective judgment. The evaluation results have strong mathematical theoretical basis. Compared with the subjective empowerment method, the weight obtained by CRITIC is more objective and realistic, and has become a method widely used in the objective empowerment method. The specific steps are as follows:

Step1. Data normalization. Due to the different measurement units of each index, some data are too large and others are too small. In order to eliminate the influence of dimension, it is necessary to normalize the data first. Assuming that there are m objects to be evaluated, n evaluation indexes, and x_{ij} are the jth indexes of the ith object to be evaluated, $j = 1, 2, \cdots, n$, $i = 1, 2, \cdots, m$,and the indexes are divided into positive indexes and negative indexes. For positive indexes, the greater the value is, the better the value is. For negative indexes, the smaller the value is, the better the value is. The normalization method of the two indexes is also different. The formula is as follows:

$$y_{ij} = \begin{cases} \dfrac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}}, \textit{positive indexes} \\ \dfrac{\max\{x_{ij}\} - x_{ij}}{\max\{x_{ij}\} - \min\{x_{ij}\}}, \textit{negative indexes} \end{cases} \tag{5}$$

where y_{ij} is the normalized processing results of x_{ij}.

Step2. Calculation of index variability.

$$V_j = \frac{\sigma_j}{\overline{y_j}}, j = 1, 2, \cdots, n \tag{6}$$

V_j is the coefficient of variation of the jth index y_j, σ_j is the standard deviation of the jth index, and $\overline{y_j}$ is the mean of the jth index.

Step3. Calculation of index confliction.

$$r_{ij} = \frac{\sum_{h=1}^{m} (y_{hi} - \overline{y_i})(y_{hj} - \overline{y_j})}{\sqrt{\sum_{h=1}^{m} (y_{hi} - \overline{y_i})^2 \sum_{h=1}^{m} (y_{hj} - \overline{y_j})^2}} \tag{7}$$

r_{ij} is the correlation coefficient between item i and item j, y_{hi} and y_{hj} are the values of item i and item j of the h object to be evaluated, $\overline{y_i}$ and $\overline{y_j}$ are the mean of item i and item j.

The confliction between index j and other indexes is T_j, and the formula is as follows:

$$T_j = \sum_{i=1}^{n} (1 - r_{ij}), i \neq j \tag{8}$$

Step4. Calculate index information. Index information is the product of index variability and index confliction, denoted as G_j.

$$G_j = V_j \times T_j, i \neq j, j = 1, 2, \cdots, n \tag{9}$$

Step5. Calculation of objective weights of indexes.

$$\omega_j = \frac{G_j}{\sum_{j=1}^{n} G_j}, j = 1, 2, \cdots, n \tag{10}$$

The greater G_j indicates that the jth index contains more information, and the weight of index j is higher.

5. Empirical analysis

5.1 Region selection and data collection

Gansu Province is located in northwestern China, including 12 prefecture-level cities and two autonomous prefectures, with a total area of 4.258 million square kilometers. By the end of 2021, the resident population of Gansu Province was 24.902 million. In 2021, Gansu Province will achieve a GDP of 102.433 billion yuan, of which the added value of the primary industry is 136.47 billion yuan, the added value of the secondary industry is 346.66 billion yuan, the added value of the tertiary industry is 541.20 billion yuan, and the per capita GDP is 40.94072 yuan. With the implementation of Gansu's western development strategy and the in-depth advancement of the "Belt and Road" construction, the study of the coupling mechanism of the regional economy and regional population mobility plays an essential role in realizing the high-quality development of the regional economy.

The index data of the regional economic and population systems in Gansu Province are derived from the Statistical Yearbook of Gansu Province 2013-2021 and the corresponding statistical bulletin on national economic and social development. The descriptive statistics of specific indicators are shown in Table 2.

Table 2 Indicator data of regional economic system and regional population mobility system in Gansu Province

Systematic name	Name of indicator	Max	Min	Mean	Mid
Regional economic system	X11/yuan	41046.00	23647.00	30621.67	29163.00
	X12/yuan	22066.00	10954.40	16257.23	16011.00
	X13/billion	10243.30	6014.50	7708.83	7336.70
	X14/billion	3466.60	2483.50	2768.60	2761.60
	X15/billion	5412.00	2682.40	4019.58	3961.20
	X16/billion	1001.80	607.27	802.71	815.73
	X17/billion	1169.70	622.44	933.52	947.01
Regional population mobility system	Y21/ten thousand people	2537.00	2490.00	2516.45	2520.00
	Y22/ten thousand square meters	2323.16	562.84	1543.73	1462.07

	Y23/km / ten thousand people	64.94	53.69	59.30	58.37
	Y4/‰	6.21	1.42	4.75	6.00

5.2 Index weight calculation

According to the importance of different indicators in the regional economic system, this study quantified seven indicators as weight indicators, including per capita GDP, per capita disposable income, local GDP, the output value of the secondary industry, output value of the tertiary industry, local fiscal revenue, and fiscal expenditure of local style broadcasting, education, science, and health services. The priority order of each indicator was: per capita disposable income > per capita GDP = local GDP > local fiscal revenue > output value of the tertiary industry > output value of the secondary industry > fiscal expenditure of local style broadcasting, education, science, and health services. The paired comparison judgment priority matrix was constructed, and the results are shown in Table 3.

Table 3 Judgement matrix score

Weight index	X1	X2	X3	X4	X5	X6	X7
X1	1	2	2	3	4	5	6
X2	1/2	1	1	2	3	4	5
X3	1/2	1	1	2	3	4	5
X4	1/3	1/2	1/2	1	2	3	4
X5	1/3	1/3	1/3	1/2	1	2	3
X6	1/5	1/4	1/4	1/3	1/2	1	2
X7	1/6	1/5	1/5	1/4	1/3	1/2	1

The weight coefficients of per capita disposable income, per capita GDP, local GDP, local fiscal revenue, the output value of the tertiary industry, the output value of the secondary industry, and the fiscal expenditure of local stylistic broadcasting, education, science, and health are 0.313, 0.199, 0.199, 0.122, 0.081, 0.051 and 0.034, respectively. The consistency scale factor (CR) = 0.022 < 0.10, that is, the index priority comparison judgment matrix is consistent, and the weight coefficient is effective.

According to the importance of different indicators in the regional population mobility system, this study quantified the four indicators, namely, the permanent population at the end of the year, the completed construction area of indemnification housing, the ratio of the total mileage of railway and highway to the total population, and the growth rate of natural population per capita GDP, as the weight indicators. The priority order of each indicator is as follows: the permanent population at the end of the year = the growth rate of natural population > the completed construction area of indemnification housing > the ratio of the total mileage of railway and highway to the total population. The priority judgment matrix is constructed, and the relative scores of each indicator are given, as shown in Table 4. According to the grading results, the analytic hierarchy process is carried out. At the end of the year, the weight coefficients of the permanent population, the natural population growth rate, the completed construction area of indemnification housing, and the ratio of the total mileage of railway and highway to the total population are 0.351, 0.351, 0.189, and 0.109, respectively. The consistency ratio factor (CR) = 0.003 < 0.10, that is, the priority comparison matrix of indicators passes the consistency test, and the weight coefficient is effective.

Table 4 Priority judgment matrix for pairwise comparison of indicators

Weight index	Y1	Y2	Y3	Y4
Y1	1	1	2	3
Y2	1	1	2	3
Y3	1/2	1/2	1	2
Y4	1/3	1/3	1/2	1

Based on the AHP method and CRITIC method constructed above, the AHP-CRITIC value is obtained by taking the average value of AHP and CRITIC, and the weight results are shown in Figure 1.

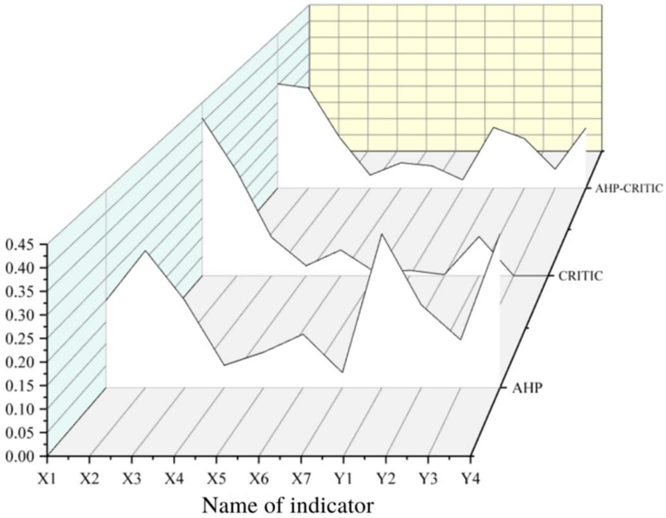

Figure 1 Weight analysis of each indicator AHP, CRITIC and AHP-CRITIC

The mixed weighting method to determine the weight coefficient CRITIC method for AHP method can more objectively evaluate the weight coefficient of the corresponding index, and the two methods are combined to calculate the total weight. Through correlation coefficient analysis, the AHP-CRITIC hybrid weighting method considers subjectivity and objectivity, and the information reflected is more comprehensive, reasonable, and realistic than a single method. Through the AHP-CRITIC weight analysis method, it is concluded that in the regional economic system, the weight of per capita GDP is the largest, 0.304, and the weight of secondary industry output value is the smallest, 0.038; in the regional population flow system, the weight of the resident population is the largest at the end of the year, which is 0.177, and the weight of the ratio of the total mileage of railway and highway to the total population is the smallest, which is 0.055.

5.3 Collaborative calculation and analysis

Starting from the order parameters of the two subsystems of the regional economy and regional population flow, this paper studies the synergy degree of the composite system of the regional economy and regional population flow and constructs the synergy evaluation model of the regional economy and regional population flow and reveals the evolution law and trend of the system.

Through Equations （2） and （3）, the order degree and the synergy degree of the composite system of the regional economy and regional population mobility subsystem in Gansu Province from 2013 to 2021 can be obtained. The order degree of the two systems and the synergy trend of the composite systems are shown in Figure 2.

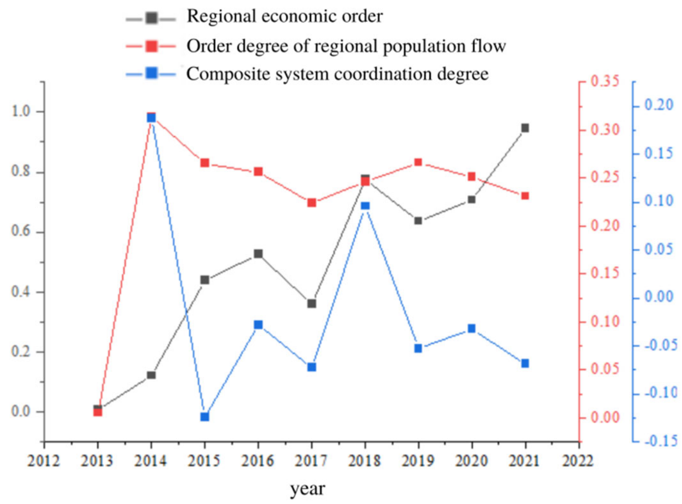

Figure 2 Trends in order and synergy between regional economy and regional population mobility in Gansu Province, 2013-2021

5.3.1 Subsystem order analysis.

It can be seen from Figure 2 that the order degree of the regional economic subsystem and the regional population flow subsystem in Gansu Province is generally on the rise. The order degree growth rate of the regional economic subsystem is significantly higher than that of the regional population flow subsystem. The relative trend of the regional population flow subsystem is relatively mild. The order degree of the regional economic subsystem increased from 0.007 in 2013 to 0.946 in 2021, and the order degree of the regional population flow subsystem increased from 0.005 in 2013 to 0.231 in 2021. The peak value of the order degree of the regional economic subsystem in 2021 was 0.94, indicating that the contribution of the two subsystems to the hybrid system is increasing. By comparing the order degree of the two subsystems of the regional economic system and regional population flow, it can be seen that in 2013-2014, the order degree of the regional population flow subsystem was significantly higher than that of the regional economic subsystem, indicating that the regional population flow is ahead of the regional economy and has a supporting and boosting effect on the regional economy. From 2015-2021, the order degree of the regional economic subsystem was significantly higher than that of the regional population mobility subsystem, the order degree of the regional economic subsystem increased rapidly, and the growth rate was higher than that of the regional population mobility subsystem.

5.3.2 Synergy analysis of a composite system.

It can be seen from Figure 2 that the synergy degree of the regional economy and regional population mobility in Gansu Province presents an M-shaped trend of alternating increase and decrease and is generally in a low-level synergy state. The overall trend of the joint degree of the composite system can be divided into four stages:

In the first stage: From 2013 to 2014, the regional economic system rebounded slightly, the regional population flow system proliferated, the orderly degree of regional population flow was higher than that of the regional economy, and the development was ahead of the regional economic system; the synergy of the hybrid system in this stage has always been A positive value indicates that the two subsystems are in a cooperative state.

In the second stage: From 2015 to 2017, the orderly degree of the regional economy first increased and then decreased, and the regional population flow declined slowly. The orderly degree of the regional economic system was always higher than that of the regional population flow system, indicating that the regional economic system was ahead of the regional population flow system. At this time, the coordination degree of the composite system is negative. That is, the two subsystems are not coordinated.

In the third stage: In 2018, the orderly degree of the regional economy and the regional population flow system will improve, and the regional economic system is still ahead of the regional population flow system; the synergy degree of the composite system is positive, and the development trend is good. In the fourth stage: From 2019 to 2021, the orderliness of the regional population flow system will decrease slightly, but the orderliness of the regional economy will increase rapidly, and the regional economic system will be ahead of the regional population flow system. The degree of the synergy of the hybrid system is negative. The two subsystems are unbalanced and cannot produce synergistic effects.

6. Conclusion

(1) In the regional economic subsystem, per capita GDP accounts for the largest weight, and local science, education, culture and health expenditure accounts for the smallest weight; in the subsystem of regional population flow, the permanent population at the end of the year accounts for the smallest weight, the ratio of the total mileage of railway and highway to the total population accounts for the smallest weight.

(2) The composite system synergy degree of regional economy and regional population flow in China ' s Gansu Province shows an alternate trend of increase and decrease from 2013 to 2021, and is generally at a low level of synergy.

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