Available online at www.ijpe-online.com

International Journal of Performability Engineering

vol. 15, no. 7, July 2019, pp. 1976-1987
DOI: 10.23940/ijpe.19.07.p25.19761987

Data Analysis of Hybrid Principal Component for Rural Land Circulation Management based on Gray Relation Algorithmic Models

Zhongbo Wang and Zhilin Suo*

College of Economics and Management, Northeast of Agricultural University, Harbin, 150001, China

Abstract

Data analysis is a common and essential process of determining the main driving factors of hybrid information principal components for rural land circulation management. To solve the existing hybrid information regarding the problem of rural land circulation in China, the main driving factors need to be confirmed based on gray relation algorithmic models in the paper. Five types of gray relation algorithmic models are adopted for hybrid Information principal component analysis for rural land circulation, such as the Deng's gray relation algorithmic model, gray absolute relation algorithmic model, T-type gray relation algorithmic model, improved gray relation algorithmic model, and gray slope relation algorithmic model. According to our collected data, the results of data analysis comparison illustrate that different gray relation algorithms may affect the order of the importance of each driving factor. The most critical driving factors are obtained as follows: the rate of non-agricultural income, the ratio of signed contracts and the ratio of peasants' spontaneous taking part in rural land circulation, which are also the most three main driving factors on the Chinese rural land circulation management.

Keywords: data analysis; quality management; rural land circulation; gray relation analysis; principal component analysis; algorithmic model

(Submitted on March 13, 2019; Revised on April 8, 2019; Accepted on June 20, 2019)

1. Introduction

Usually, it is difficult to determine the main factors affecting the development of a complex hybrid information system. In 1982, Deng proposed the gray system theory, which combines the advantages of system theory, information theory, and cybernetics. It can effectively extract valuable information from limited information in an uncertain system with a small number of samples and make an effective description of the development for a complex hybrid information system [1].

When analyzing a complex hybrid information system, the primary and secondary factors that enhance or restrict the development of the system should be analyzed and distinguished. Gray relation analysis (GRA) theory can be used to quantify the importance of the factors in the complex hybrid information system based on a small number of samples. The GRA method has been applied in many fields. It can be used to evaluate the effectiveness of programs [2] and predict software defects [3]. In order to quantify the relationship between different factors, various forms of correlation coefficients have been proposed, such as the canonical correlation coefficient and resemblance correlation coefficient. These correlation coefficients are obtained based on the mathematical statistic theory and require a large number of samples. However, in practice, it is hard to meet this requirement because the amount of statistical data is limited. Therefore, the method based on mathematical statistic theory is not suitable to analyze the main factors in a complex hybrid information system based on a small number of samples. Aiming at the above problem, the GRA method can effectively overcome this shortcoming, and there is no requirement for the sample size and data distribution [4]. The following models are some commonly used gray relation algorithms. One of the most fundamental models is Deng's gray relation analysis model, proposed by Deng Julong based on the gray relation analysis axiom [5-6]. The B-type gray relation analysis (B-GRA) was proposed by Wang Qingyin (1989) according to the proximity and similarity between two objects [7]. The gray absolute relation grade (GARG) model was proposed by Mei Zhenguo in 1992 based on the adjacency degree of absolute trends and relative trends between two time series curves. The T-type gray relation analysis (T-GRA) model was proposed by Tang Wuxiang in 1995 based on the

* Corresponding author.
E-mail address: szl1960@sina.com

approaching degree between two time series curves [8-10]. The gray slope relation grade (GSRG) model was proposed by Dang Yaoguo in 1994 and later developed by Dang Yaoguo and Sun Yugang in 2007 [11-13]. The generalized gray relation grade was discussed based on the generalized interval by Wang Qingyin and Guo Litian in 2005 [14]. The defects of gray relation grade have been discussed, and some corresponding improvements have been proposed [15-20]. The contradiction of the GRA axiom was pointed out and proven [21], which means that the GRA axiom is imperfect to define the GRA. However, the advantage of the above methods is that there is no need for the quantity and regularity of the samples, and there is also no need to consider the coupling symmetry and wholeness in the practical application. Therefore, the above GPA methods have been widely used to analyze the hybrid information principal components. In reference [22], the GRA method was used to exploit the relationship between the shipping exchange and port economy. In reference [23], different levels of combinations of the factors were ranked based on the GRA method. In reference [24], the security risk of information systems based on D-S theory and the GRA method was assessed. In reference [25], the GRA method was used to select the appropriate business manager. In reference [26], the GRA theory was used to analyze the main factors of corrosion of oil tubes. In reference [27], the GRA method was used to exploit the turning operation being affected by cutting parameters and the tool nose radius. In reference [28], information security controls were evaluated based on the GRA method. In reference [29], the GRA method was used to conduct the proper parameters in the application of single point incremental forming.

In China, the problem of rural land circulation has been widely concerned. Policies regarding land management rights have been mentioned in the "NO.1 Central Document" for over a decade from 2005 to 2016. "Three Rural Issues" have always been crucial issues related to the development of the society, politics, and economy. The problem of rural land circulation has also aroused great concern in academia. Many scholars have studied rural land circulation in economics, sociology, and political science. The driving factors that promote the rural land circulation in microcosm mainly depend on the farmers' attitudes. Usually, correlation analysis, regression analysis, and other statistical methods are used to analyze the main factors that can influence the rate of rural land circulation. These methods require a large number of surveys and effective data as support, and the sample data must obey a typical probability distribution to some extent [30].

This paper introduces some related concepts of GRA and several typical GRA models. The main factors influencing rural land circulation by using GRA theory are analyzed, in which relevant data in certain rural areas during the period from 2004 to 2009 are taken as example.

2. Gray Relation Analysis

The fundamental of GRA is to calculate the multiple factors GRG by comparing the degree of similarity of the geometry between two statistical series curves in a system. The lower the difference of geometry between the two sequence curves, the greater their correlation degree.

2.1. The Basic Concept of GRA

Before analyzing a complex hybrid information system, some features that can reflect the system should be selected. The data sequences that reflect the features' behavioral tendency are mapping vectors, which represent the system behavior indirectly. Some basic concepts of GRA are defined as follows.

1) The reference sequence is as follows. If X_0 is the variable that reflects the system behavior and $x_0(k)$ is the data of the sequence number $k(k=1,2,\cdots,n)$, and $X_0(k)=(x_0(1),x_0(2),\cdots,x_0(n))$ is the reference sequence of the system.

2) The objective sequence is as follows. Let X_i be the system factors and $x_i(k)$ represent the observation data of the serial number $k(k=1,2,\cdots,n)$, and $X_i(k)=(x_i(1),x_i(2),\cdots,x_i(n))$ is the objective sequence of the system.

3) The gray relation coefficient is the measure of the comparison between $x_0(k)$ and $x_i(k)$.

4) The gray relation grade is the correlation degree between X_0 and X_i, and it can be written as $\gamma(X_0,X_i)$.

5) The gray relation ordinal is as follows. If $\gamma(X_0,X_i)$ is bigger than $\gamma\left(X_0,X_j\right)$, then $X_i \succ X_j \succ$ is called the gray relation ordinal derived from GRG [31].

2.2. Nondimensionalization

After the system features and the system behavioral influencing factors are defined, the mapping vectors need to be dealt with properly before quantitative analysis, by turning them into non-dimensional data with similar order of magnitude [32]. The processing is the first step of gray system analysis and modeling. The data from a large amount of information and statistics through different channels is usually called raw data. The order of magnitude and the units of the measurement of the raw data are different, and they cannot be calculated directly. These raw data has the following characteristics [33].

1) Most of the dimensions are different because the indictors are different, even if the dimensions are same, and the orders of magnitude may be hugely different.

2) Most of the data is scattered and has evident randomness.

3) Most of the data has a gray degree because the information is incomplete and vague.

If the data is used to analyze the system directly, the calculation will be distorted and the analysis results will be deviated. To guarantee the quality of the model and the reliability of analysis results, some kinds of mathematical methods should be used to transform the raw data, and this process is called data preprocessing. The processed data should meet the following requirements.

1) The dimension of data used to analyze the system is unified.

2) The order of magnitude of factors or sequences can be compared.

3) The processed data can show its rudimentary distribution trend.

4) The nonlinear relationship between the factors is transformed into a linear relationship as much as possible.

Single Index Sequence Transformation:

1) Initial transformation (IT):

$$XD_1 = \left(\frac{x(1)}{x(1)}, \frac{x(2)}{x(1)}, \cdots, \frac{x(n)}{x(1)} \right) \tag{1}$$

Where $x(1) \neq 0,\ k = 1, 2, \cdots, n$.

2) Mean transformation (MT):

$$XD_2 = \left(\frac{x(1)}{\bar{X}}, \frac{x(2)}{\bar{X}}, \cdots, \frac{x(n)}{\bar{X}} \right) \tag{2}$$

Where $\bar{X} = \frac{1}{n}\sum_{k=1}^{n} x(k)$, $\bar{X} \neq 0,\ k = 1, 2, \cdots, n$.

3) Multiple transformation (MULT):

$$XD_3 = \left(\frac{x(1)}{\min x(k)}, \frac{x(2)}{\min x(k)}, \cdots, \frac{x(n)}{\min x(k)} \right) \tag{3}$$

Where $k = 1, 2, \cdots, n$.

4) Normalization transformation (NT):

$$XD_4 = \left(\frac{x(1)}{x_0}, \frac{x(2)}{x_0}, \cdots, \frac{x(n)}{x_0} \right) \tag{4}$$

Where x_0 is a constant that is bigger than zero, $k = 1, 2, \cdots, n$.

5) Range maximization transformation (RMT):

$$XD_5 = \left(\frac{x(1) - \min x(k)}{\max x(k) - \min x(k)}, \cdots, \frac{x(n) - \min x(k)}{\max x(k) - \min x(k)} \right) \tag{5}$$

Where $k = 1, 2, \cdots, n$.

If the single index sequence is $X = (x(1), x(2), \cdots, x(n))$, the sequence transformation should have the following qualities.

$$\begin{aligned} x(k)d_1 &= x(k) / x(1) \\ x(k)d_2 &= x(k) / \bar{X} \\ x(k)d_3 &= x(k) / \min x(k) \\ x(k)d_4 &= x(k) / x_0 \\ x(k)d_5 &= (x(k) - \min x(k)) / (\max x(k) - \min x(k)) \end{aligned} \tag{6}$$

1) If $x(k) \geq 0$, then $x(k)d_j \geq 0,\ j = 1, 2, \cdots, 5$;

2) If $x(k_1), x(k_2) \in X$ and $x(k_1) > x(k_2)$, then $x(k_1)d_j \geq x(k_2)d_j,\ j = 1, 2, \cdots, 5$;

3) If $x(k_1), x(k_2) \in X$ and $x(k_1) < x(k_2)$, then $x(k_1)d_j < x(k_2)d_j,\ j = 1, 2, \cdots, 5$;

4) If $x(k_1), x(k_2), x(k_3), x(k_4) \in X$, then $\frac{x(k_1) - x(k_2)}{x(k_3) - x(k_4)} = \frac{x(k_1)d_j - x(k_2)d_j}{x(k_3)d_j - x(k_4)d_j},\ j = 1, 2, \cdots, 5$.

3. Typical GRA

If the reference sequence is $X_0 = (x_0(1), x_0(2), \cdots, x_0(n))$, the objective sequence is $X_i = (x_i(1), x_i(2), \cdots, x_i(n))$, and $(i = 1, 2, \cdots, m)$. $\varepsilon_{0i}(k)$ is the gray relation coefficient (GRC) $(k = 1, 2, \cdots, n)$, and $\gamma(X_0, X_i)$ is the gray relation grade.

3.1. Deng's Gray Relation Grade

Deng's gray relation grade (GRG) is a commonly used method that was proposed by Deng Julong. It is applied to denote the relation degree between multiple factors in gray systems [34].

GRC is as follows:

$$\varepsilon_{0i}(k) = \frac{mm + \rho \cdot MM}{|x_0(k) - x_i(k)| + \rho \cdot MM} \tag{7}$$

GRG is as follows:

$$\gamma(X_0, X_i) = \frac{1}{n} \cdot \sum_{i=1}^{n} \varepsilon_{0i}(k) \tag{8}$$

Where $mm = \min_i \min_i |x_0(k) - x_i(k)|$, $MM = \max_i \max_i |x_0(k) - x_i(k)|$, and $\rho \in (0, +\infty)$. ρ is the distinguishing coefficient. The smaller the ρ, the stronger the distinguishing capability, and usually $\rho = 0.5$.

Deng's gray relation model fully reflects the constraint condition of the GRA axiom. The calculation focuses on the influence of the distance between two points on the relation degree. However, the main disadvantages are as follows: the relation degree lacks normalization; both GRC and GRA are likely to be affected by ρ ; only the positive correlation, rather than the negative correlation, between two curves can be reflected; and it does not have isotonicity after the non-dimensional disposal [35-36].

3.2. Gray Absolute Relation Analysis (*GARA*)

In 1992, Mei Zhenguo proposed gray absolute relation grade (GARG) according to the proximity degree of the changing tendency of the factors' time series curves [37].

If the references are not the same or the references cannot be compared, the disadvantages of Deng's GRA may occur. The gray absolute relation analysis method can solve the above problem.

The GARG is as follows.

$$\gamma(X_0, X_i) = \frac{1+|s_0|+|s_i|}{1+|s_0|+|s_i|+|s_i-s_0|} \tag{9}$$

$$|s_0| = \left|\sum_{k=2}^{n-1} x_0(k) + \frac{1}{2}x_0(n)\right|,\ \ |s_i| = \left|\sum_{k=2}^{n-1} x_i(k) + \frac{1}{2}x_i(n)\right| \tag{10}$$

$$|s_i - s_0| = \left|\sum_{k=2}^{n-1}\left[x_i(k)-x_0(k)\right] + \frac{1}{2}\left[x_i(n)-x_0(n)\right]\right| \tag{11}$$

It mainly studies the relationship between the absolute increments of two sequences and measures the relevance between two sequences by the area between two lines. The GARG overcomes some disadvantages of Deng's GRA and disuses the distinguishing coefficient. However, this method cannot satisfy the normalization requirement and does not possess isotonicity after non-dimensional disposal.

3.3. Improved Gray Slope Relation Analysis

In 1994, Dang Yaoguo improved the GRA model based on the GARA model and Deng's GRA model. The improved gray slope relation analysis method overcomes some disadvantages of the gray absolute relation model. In addition, some patented inventions based on gray relation analysis have also made some effective improvements to the traditional gray relation analysis method [38].

The GSRC is as follows.

$$\gamma(X_0, X_i) = \frac{1}{n-1}\sum_{j=1}^{n-1}\left\{k_{ij}c/\left[c+\mathrm{tg}(U_j/2)\right]\right\} \tag{12}$$

Where

$$k_{ij} = 1 - \frac{|X_i(k)-X_0(k)|}{\sum_{k=1}^{n}|X_i(k)-X_0(k)|} \tag{13}$$

$$U_j = \mathrm{arctg}\left[\frac{(X_i(k+1)-X_i(k))-(X_0(k+1)-X_0(k))}{1+(X_i(k+1)-X_i(k))\cdot(X_0(k+1)-X_0(k))}\right] \tag{14}$$

3.4. T-Type Gray Relation Analysis

In 1995, T-type gray relation analysis (T-GRA), which can reflect positive correlation and negative correlation between two curves, was proposed by Tang Wuxiang based on the adjacency degree of the relative trends of factors' time series curves [39].

The T-GRA is as follows.

$$\gamma = \frac{1}{n-1}\sum_{k=2}^{n}\varepsilon_{0i}(k) \tag{15}$$

Where

$$\varepsilon_{0i}(k) = \begin{cases} \operatorname{sgn}(\Delta y_0(k)\cdot\Delta y_i(k))\dfrac{\min(|\Delta y_0(k)|,\Delta y_i(k))}{\max(|\Delta y_0(k)|,\Delta y_i(k))}, & \Delta y_0(k)\cdot\Delta y_i(k)\neq 0 \\ 0, & \Delta y_0(k)\cdot\Delta y_i(k) = 0 \end{cases} \tag{16}$$

$$D_0 = \frac{1}{n-1}\sum_{k=2}^{n}|\Delta x_0(k)| = \frac{1}{n-1}\sum_{k=2}^{n}|x_0(k)-x_0(k-1)|,\ k = 2,3,\cdots,n \tag{17}$$

$$\Delta y_0(k) = \frac{x_0(k)-x_0(k-1)}{D_0} \tag{18}$$

$$\Delta y_i(k) = \frac{x_0(k)-x_i(k-1)}{D_0} \tag{19}$$

Its disadvantage is that the relation of certain increments would be magnified or weakened if all the data is process dimension regardless of the situation, which will result in a wrong conclusion.

3.5. Gray Slope Relation Analysis

In 1994, Dang Yaoguo proposed the gray slope relation grade (GSRG), and this method calculates the degree according to the adjacency degree of the average relative trends of the factors' time series curves [40-41].

The GSRC is as follows.

$$\gamma(X_0, X_i) = \frac{1}{n-1}\sum_{k=1}^{n-1}\varepsilon_{0i}(k) \tag{20}$$

Where

$$\varepsilon_{0i}(k) = \frac{1}{1+\left|\dfrac{x_i(k+1)-x_i(k)}{x_i(k+1)} - \dfrac{x_0(k+1)-x_0(k)}{x_0(k+1)}\right|} \tag{21}$$

Although the GSRG has isotonicity after non-dimensional disposal, it cannot satisfy the normalization requirement or reflect the negative correlation of the factors.

In fact, the definition of relation grade is not ideal; it measures the relation degree between factors according to the adjacency degree of the data columns' geometry and trends only. Many relation grade formulas can be established when researching the relation degree between factors according to the idea of similar geometry. The analysis based on the formulas mentioned above does not lead to the same conclusion. Therefore, it would be better to run calculations of diverse types.

In practical work, the sensitivity of gray relation ordinal should be noticed. When using different non-dimensional methods to transform the raw data and different distinguishing coefficients, the order of the gray relation ordinal will be different. How to determine the objective standard for gray relation grades and which kind of non-dimensional method should be chosen are the problems.

4. Parameters Estimation in GLD

Figure 1 is the analysis chart of the main factors of rural land circulation based on GRA.

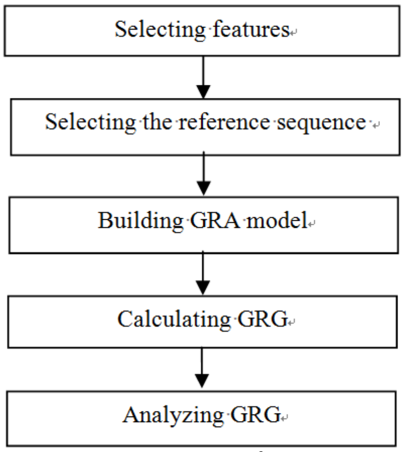

Figure 1. Process of GRA

Step 1 Select features

After some investigations, whether the peasants are willing to participate in rural land circulation (RLC) depends on three factors: the income, the risk, and the safeguard of RLC. Through research and analysis, the following nine items of three types are selected as the indexes influencing RLC.

1) The income of RLC: The net income of circulation peasant (NICP) x_1, non-agricultural income rate (NAIR) x_2, and the ratio of before and after the income of circulation (RBAIC) x_3.

2) The risk of RLC: The loss probability of the peasant who contracted land (LPPCL) x_4, the violation probability of rural land circulation (VPRLC) x_5, the ratio of signed contracts (RSC) x_6, and the ratio of peasants spontaneously taking part in rural land circulation (PPSRLC) x_7.

3) The security of RLC: The reemployment probability of the rural land circulation peasants (RPRLCP) x_8 and the guarantee rate of foodstuff security (GRFS) x_9.

The feature sequence is $X = (x_1, x_2, \cdots, x_9)$.

Step 2 Build a GRA model

Take for example the relevant data of Longhui, Dongkou, Wugnag of Hunan province from 2004 to 2009, which is shown in Table 1. Supposing the ratio of rural land circulation (RRLC) (the area of RLC / the total area of rural land) is the reference sequence X_0 and the nine factors are the objective sequences X_i, T-GRG, Deng's GRG, GARG, and GSRG are chosen as the calculation model.

The reference sequence:

$$X_0 = (0.221, 0.224, 0.232, 0.237, 0.243, 0.248)$$

Table 1. The value of influence factors of rural land circulation

Factors \ Year	2004	2005	2006	2007	2008	2009
RRLC x_0	0.221	0.224	0.232	0.237	0.243	0.248
NICP x_1	3850	4000	4350	4580	4730	5200
NAIR x_2	0.69	0.70	0.71	0.71	0.75	0.79
RBAIC x_3	1.11	1.12	1.13	1.12	1.13	1.13
LPPCL x_4	0.09	0.10	0.11	0.13	0.12	0.10
VPRLC x_5	0.07	0.08	0.08	0.09	0.08	0.08
RSC x_6	17.2	17.5	18.3	19.6	21.3	22.8
PPSRLC x_7	23.5	23.8	24.1	24.9	25.1	26.9
RPRLCP x_8	0.814	0.825	0.837	0.854	0.879	0.912
GRFS x_9	0.561	0.572	0.583	0.552	0.538	0.526

The objective sequences:

$$X_1 = (3850, 4000, 4350, 4580, 4730, 5200)$$
$$X_2 = (0.69, 0.70, 0.71, 0.71, 0.75, 0.79)$$
$$\vdots$$
$$X_9 = (0.561, 0.572, 0.583, 0.552, 0.538, 0.526)$$

Step 3 Calculate the grade

Calculate the relation grade between the factors and the rate of rural land circulation based on T-GRG, Deng's GRG, GARG, IGRG, and GSRG. The raw data uses the initial transformation method.

According to Tables 2-6, using the different relation grade model leads to different results. Non-dimension may affect the analysis. T-GRA and GSRG have isotonicity after being applied with the dimensionless methods, and T-GRA can reflect the negative correlation between factors.

According to Table 7, although the different non-dimension transformation methods lead to different gray relation grades, the orders of factors are approximately the same: $x_8 \succ x_3 \succ x_7 \succ x_2 \succ x_6 \succ x_1 \succ x_9 \succ x_5 \succ x_4$. Table 8 shows that different non-dimension transformation methods lead to different results. The order based on initial transformation is

$$x_8 \succ x_7 \succ x_2 \succ x_3 \succ x_6 \succ x_9 \succ x_5 \succ x_1 \succ x_4$$

The order based on mean transformation is

$$x_8 \succ x_7 \succ x_2 \succ x_3 \succ x_1 \succ x_5 \succ x_6 \succ x_9 \succ x_4$$

The order based on multiple transformation is

$$x_8 \succ x_7 \succ x_2 \succ x_3 \succ x_6 \succ x_5 \succ x_9 \succ x_1 \succ x_4$$

The order based on range maximization transformation is

$$x_8 \succ x_7 \succ x_2 \succ x_6 \succ x_3 \succ x_5 \succ x_1 \succ x_9 \succ x_4$$

Step 4 Analyze the GRG

To take all these factors into account, the rate of non-agricultural income, the rate of signed contracts, and the probability of peasants spontaneously taking part in rural land circulation have more influence on the rate of RLC.

Table 2. T-GRA (whether possess non-dimension)

Order	YES	Influence factors	No	Influence factors
1	0.7662	NICP x_1	0.7654	NICP x_1
2	0.7522	RPRLCP x_8	0.7522	RPRLCP x_8
3	0.6369	RSC x_6	0.6371	RSC x_6
4	0.4983	PPSRLC x_7	0.4987	PPSRLC x_7
5	0.4512	NAIR x_2	0.4512	NAIR x_2
6	0.2873	RBAIC x_3	0.2873	RBAIC x_3
7	-0.1642	GRFS x_9	-0.1643	GRFS x_9
8	0.1229	LPPCL x_4	0.1234	LPPCL x_4
9	0.0446	VPRLC x_5	0.0444	VPRLC x_5

Table 3. Deng's GRA (whether possess non-dimension)

Order	YES	Influence factors	No	Influence factors
1	0.9466	RPRLCP x_8	1.0000	LPPCL x_4
2	0.9272	PPSRLC x_7	0.9999	VPRLC x_5
3	0.9222	NAIR x_2	0.9999	GRFS x_9
4	0.8187	RBAIC x_3	0.9998	RPRLCP x_8
5	0.7823	RSC x_6	0.9998	NAIR x_2
6	0.7774	GRFS x_9	0.9997	RBAIC x_3
7	0.7389	VPRLC x_5	0.9927	RSC x_6
8	0.7053	NICP x_1	0.9907	PPSRLC x_7
9	0.6492	LPPCL x_4	0.3702	NICP x_1

Table 4. GARG (whether possess non-dimension)

Order	YES	Influence factors	No	Influence factors
1	0.9636	PPSRLC x_7	0.9961	RBAIC x_3
2	0.9595	NAIR x_2	0.9907	VPRLC x_5
3	0.9589	RPRLCP x_8	0.9674	LPPCL x_4
4	0.8154	NICP x_1	0.9296	GRFS x_9
5	0.8549	RSC x_6	0.9284	NAIR x_2
6	0.8535	RBAIC x_3	0.9110	RPRLCP x_8
7	0.8097	VPRLC x_5	0.5464	PPSRLC x_7
8	0.8027	GRFS x_9	0.5252	RSC x_6
9	0.7389	LPPCL x_4	0.5001	NICP x_1

Table 5. GSRG (whether possess non-dimension)

Order	YES	Influence factors	No	Influence factors
1	0.9919	RPRLCP x_8	0.9919	RPRLCP x_8
2	0.9812	RBAIC x_3	0.9812	RBAIC x_3
3	0.9811	PPSRLC x_7	0.9811	PPSRLC x_7
4	0.9802	NAIR x_2	0.9802	NAIR x_2
5	0.9696	RSC x_6	0.9696	RSC x_6
6	0.9663	NICP x_1	0.9663	NICP x_1
7	0.9635	GRFS x_9	0.9635	GRFS x_9
8	0.9267	VPRLC x_5	0.9267	VPRLC x_5
9	0.8944	LPPCL x_4	0.8944	LPPCL x_4

Table 6. IGRG (whether possess non-dimension)

Order	YES	Influence factors	No	Influence factors
1	0.8788	RSC x_6	0.8299	RPRLCP x_8
2	0.8598	NICP x_1	0.6748	PPSRLC x_7
3	0.5325	LPPCL x_4	0.6633	NAIR x_2
4	0.4876	NAIR x_2	0.6013	RSC x_6
5	0.3551	VPRLC x_5	0.5016	LPPCL x_4
6	0.2784	PPSRLC x_7	0.5006	RBAIC x_3
7	0.2712	RPRLCP x_8	0.4216	NICP x_1
8	0.2153	GRFS x_9	0.3359	VPRLC x_5
9	0.0089	RBAIC x_3	0.3337	GRFS x_9

Table 7. The GSRG based on the different non-dimension transformation methods

Factors	IT	MT	MULT	RMT
x_1	0.9663	0.9644	0.9571	60.9712
x_2	0.9802	0.9793	0.9783	40.9810
x_3	0.9812	0.9809	0.9797	20.9822
x_4	0.8944	0.8910	0.8714	90.9077
x_5	0.9267	0.9241	0.9152	80.9313
x_6	0.9696	0.9672	0.9616	50.9738
x_7	0.9811	0.9801	0.9791	30.9816
x_8	0.9919	0.9916	0.9912	10.9921
x_9	0.9635	0.9635	0.9616	70.9653

Table 8. Deng's GRA based on the different non-dimension transformation methods

Factors	IT	MT	MULT	RMT
x_1	0.7053	0.6897	80.7053	70.7073
x_2	0.9222	0.8648	30.9222	30.8990
x_3	0.8187	0.7478	40.8187	50.7805
x_4	0.6492	0.5497	90.6492	90.6275
x_5	0.7389	0.6589	60.7389	60.7431
x_6	0.7823	0.6531	50.7823	40.7919
x_7	0.9272	0.8747	20.9272	20.9043
x_8	0.9466	0.9055	10.9466	10.9303
x_9	0.7774	0.6055	70.7357	80.6729

5. Conclusions

The main driving factors on Chinese rural land circulation management obtained by data analysis of hybrid information based on different gray relation algorithmic models. The analysis results present there are three main driving factors affecting the rural land circulation in China, which are the rate of non-agricultural income, the ratio of signed contracts and the ratio of peasants' spontaneous taking part in rural land circulation). It is effective and efficient for gray relation algorithms to obtain the most influential driving factors on the rural land circulation in China based on our collected samples.

The data analysis results also illustrate that different gray relation algorithms (i.e., the Deng's gray relation analysis model, gray absolute relation analysis model, T-type gray relation analysis model, improved gray relation analysis model and gray slope relation analysis model) may affect the order of the importance of each driving factor. In the future work, in order to obtain a more exact solution, the evidence fusion theory can be used to fuse the analysis results obtained by different gray relation algorithmic models.

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