Research on the Model of Regional Circular Economics Based on Computer Modelling

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Abstract. This thesis takes the geographical area resource coverage as an example and uses computer theory to model circular economics. The thesis establishes a multi-objective regional economic resource optimization allocation model, uses MATLAB language to write programs, and obtains the results of resource optimization allocation based on the results of resource supply and demand forecast analysis. Finally, the paper analyses the results of resource optimization allocation, and realizes the coordinated development of society, economy and environment based on sustainable development.

Keywords: V Computer, regional economy, geographic economy, circular economics, computer modelling.

1. Introduction
The optimal allocation of resources can effectively promote the rational and effective use of resources, and ensure the greatest possible satisfaction of the coordinated development of society-economy-resources-environment. It not only considers economic benefits, but also considers social and environmental benefits to achieve comprehensive social, economic and environmental benefits. The process of resource optimal allocation is the process of human being's redistribution and distribution of resources. It can not only have a good impact on the ecological and geographical environment, promote the sustainable development of the economy and society, but also cause the deterioration of the ecological environment and affect the normal development of the economy and society. Therefore, the quality of resource allocation is not only related to the rise and fall of the ecosystem on which it depends, but also to the strength of the sustainable development strategy of resources [1]. Research and practice must be strengthened to facilitate the coordinated development of society, economy and the ecological environment. Establishing a resource and energy saving society is an inevitable choice to solve the problem of resource shortage in our country. It will help reduce pollution emissions and improve the ecological environment. It is an important measure for the development of circular economy. Under the guidance of comprehensive resource planning, the establishment of a distribution system for initial resource rights is the initial stage of a resource and energy conservation society. On this basis, a resource and energy-saving social management system featuring government regulation, market guidance, and public participation will be established to achieve unified management of river basin resources and regional energy affairs.
2. Overall model establishment

2.1. General idea

The optimal allocation of resources is the use of systems engineering theory to optimally allocate regional resources among districts and resource-consuming departments. That is to establish an optimization model with objective function and constraint conditions.

First of all, it is necessary to divide sub-regions, determine resource channels, and resource consumption departments. The thesis assumes that the research area is divided into K sub-areas, k=1, 2, K; the k sub-areas have I(k) independent resources and J(k) resource-consuming departments. There are M public resources in the study area, c=1, 2, ..., M. The number of resources allocated to the k sub-area of the common resource c is denoted by \( D^c_k \). The amount of its resources, like other independent resources, needs to be allocated among the end users of each resource consuming. Therefore, for the k sub-area, I(k)+M resources and J(k) resources consume the resource optimization allocation problem of the end user. Second, the model goals need to be determined. The resource optimization allocation model oriented to sustainable development seeks to maximize the comprehensive benefits of society, economy and environment. According to the different methods of establishing the objective function, it can be divided into a multi-objective model and a single-objective model. Finally, list all the constraints of the model [2]. Figure 1 shows the basic flow chart for model building.

![Figure 1. The basic process model of resource recycling economy](image)

2.2. Model establishment

The resource optimization allocation model, like the general optimization model, should be composed of objective functions and constraints. The general form is as follows:

\[
\max \left( \min \left[ f_1(x), f_2(x), f_3(x) \right] \right)
\]

\[\text{s.t. } G(x) \leq 0, x \geq 0\]

In the above formula: x is the decision variables \( f_1(x) \), \( f_2(x) \), and \( f_3(x) \) are economic benefits, environmental benefits, and social benefits, respectively; \( G(x) \) is the set of constraints, representing resource carrying capacity, environmental capacity, Land resources, other social constraints, and subsystem state equations, etc.
2.2.1. **Objective function.** Since the optimal allocation of resources must consider at least social benefits, economic benefits, and environmental benefits, the objective function can be divided into three goals, and then integrated benefits [3]. This is the multi-objective optimization model.

**Social benefits:** Since social benefits are not easy to measure, they can be reflected indirectly by the smallest total regional deficit. Because the size of the regional shortage directly affects social development and stability, it is a side reflection of social benefits:

\[
\min f_1(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} D_j^k - \sum_{k=1}^{K} \sum_{j=1}^{J} \sum_{i=1}^{I} x_{ij}^k
\]

(2)

In the above formula: \(D_j^k\) is the demand of users in subarea \(k\) (ten thousand m\(^3\)), and \(x_{ij}^k\) is the supply of users of \(i\) resource \(j\) in subarea \(k\) (ten thousand m\(^3\)).

**Economic benefits:** quantify with the largest GDP:

\[
\max f_2(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} gdp_j \sum_{i=1}^{I} x_{ij}^k
\]

(3)

In the above formula: \(gdp_j^k\) is the unilateral output value coefficient of the production sector in subarea \(j\), which is represented by unilateral GDP.

**Environmental benefits:** Environmental issues directly related to resource utilization, quantified by the maximum guarantee rate of ecological environment user supply:

\[
\max f_3(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} s_j \sum_{i=1}^{I} x_{ij}^k / \sum_{j=1}^{J} s_j
\]

(4)

In the above formula: \(s_j\) is the demand of ecological user \(j\) (10,000 m\(^3\)).

2.2.2. **Constraints.** On the one hand, it can be analyzed separately from each link of the resource allocation system; on the other hand, it can be analyzed from the coordination of society, economy, resources, and ecological environment. There are mainly the supply capacity constraints of the supply system, the transportation capacity constraints of the transportation system, the supply and demand change constraints of the dosage system, the quality constraints of the displacement system, the regional coordinated development constraints, non-negative constraints and some other constraints [4]. In order to determine the most reasonable supply of each resource, the supply should be as close as possible to the configuration target, that is, the objective function value of the optimization model is the largest or the smallest, and the supply of each source must meet certain conditions, which is reflected in the set of constraints of the optimization model on.

**Resource availability constraints:**

\[
\sum_{j=1}^{J} x_{ij} \leq W_i
\]

(5)

In the above formula: \(W_i\) is the supply of \(i\) resources (ten thousand m\(^3\)).

**Engineering output constraints:**

\[
x_{ij} \leq Q_{ij}
\]

(6)

In the above formula: \(Q_{ij}\) is the transmission capacity provided by resource \(i\) to user \(j\) (ten thousand m\(^3\)).
Constraints on demand by sector:

\[ D_{j, \text{min}}^k \leq \sum_{i} x_{ij} \leq D_{j, \text{max}}^k \]  

(7)

In the above formula: \( D_{j, \text{min}}^k \), \( D_{j, \text{max}}^k \) is the lower limit and upper limit of the change in user demand in sub-zone \( j \) of \( k \).

Non-negative constraints on decision variables:

\[ x_{ij} \geq 0 \]  

(8)

Combining the above objective function and various constraints together constitutes a multi-objective overall model for the optimal allocation of regional resources. The model is as follows:

\[
F(X) = \text{opt}\{f_1(x), f_2(x), f_3(x)\} = \begin{cases} 
\min f_1(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} D_{j}^k - \sum_{k=1}^{K} \sum_{j=1}^{J} x_{ij} & \sum_{j} x_{ij} \leq W_i \\
\max f_2(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} gdp_j^k x_{ij} & x_{ij} \leq O_j \\
\max f_3(x) = \sum_{k=1}^{K} \sum_{j=1}^{J} x_{ij} / \sum_{k=1}^{K} \sum_{j=1}^{J} x_{ij} & D_{j, \text{min}}^k \leq \sum_{i} x_{ij} \leq D_{j, \text{max}}^k \\
x_{ij} \geq 0 & 
\end{cases}
\]

(9)

3. Multi-model solution

Since the objective functions in a multi-objective optimization problem are often unfair, there is no unique solution. In comparison, there is only an effective solution, that is, there is no better solution than an effective solution within the allowable range [5]. There are many solutions to multi-objective optimization problems, and some common ones are introduced below.

3.1. Power and Law

This method transforms the objective function problem into a scalar problem of all objective weights, namely: \( \min_{x \in \Omega} \sum_{i=1}^{m} \omega_i \ast F_i(x)^2 \), Among them, there are many methods for selecting weighting factor \( \omega_i \), including expert scoring method, \( \alpha \) method, tolerance method and weighted factor decomposition method.

3.2. Goal achievement method

The objective function series is \( F(x) = \{F_1(x), F_2(x), \ldots, F_m(x)\} \), correspondingly its target value series \( F^* = \{F_1^*, F_2^*, \ldots, F_m^*\} \). The objective function is allowed to have positive and negative deviations, and the size of the deviation is controlled by the weighting coefficient vector \( W = \{w_1, w_2, \ldots, w_m\} \). Therefore, the multi-objective problem can be transformed into a standard optimization problem:

\[
\min_{x \in R, y \in \Omega} \gamma \sub F(x) - \omega \gamma \leq F_i^* \sub, i = 1, 2, \ldots, m
\]

(10)

This article uses MATLAB programming to solve the multi-objective model. MATLAB is recognized internationally as the most excellent application software and development environment in
the field of science and technology. MATLAB originated from the combination of matrix (matrix) and laboratory (laboratory). It is a powerful engineering language. Since Mathworks was introduced to the market in 1984, the version has been continuously updated. After more than ten years of development and competition, it has become one of the most popular science and technology application software in the world and has gradually taken the world by storm [6]. MATLAB has reliable numerical and symbolic computing capabilities, simple and easy-to-learn programming language, powerful graphics and visualization functions, and numerous application toolkits (Toolbox). This is a significant feature that distinguishes MATLAB from other technology applications. MATLAB's numerical calculation functions include: creation and storage of matrices; numerical matrix algebra, exponetiation and decomposition; array operations; matrix operations; polynomial and rational fraction operations; data statistical analysis, difference and numerical derivatives; used to calculate integrals, Functional functions for optimization and numerical solutions of differential equations, etc. Its symbolic functions include: matrix operations, calculus, polynomial and rational fraction operations, algebraic equations, differential equations, equations, graph theory, number theory, etc.

The basic optimization idea of this tool function uses the target approximation method. The target approximation method refers to the establishment of a set of expected design target values \( \{f_1(x), f_2(x), f_n(x)\} \), so that the distance between the non-inferior solution set and the target set is the smallest, that is, near the expected value, introduce a slack variable \( w_i \times r \), and the non-inferior solution with the smallest slack is the most feasible solution for the target \( F^* \). The standard form is as follows:

\[
\min_{\sum_{i=1}^{r}w_i \leq F^*} \left( x \right) - w_i \times r
\]

4. Economic model verification

Since 2017, the economic development of the five north western provinces has made tremendous progress. Prior to 2018, the per capita GDP of the five north western provinces maintained rapid growth. However, in 2018, due to the impact of the financial crisis, the economic development of various regions was impacted. The per capita GDP growth rate of the north western region declined, and it began to rebound after 2019. After 2020, the growth rate of per capita GDP in the Northwest Region has shown a declining growth. In recent years, the country has paid more and more attention to the adjustment of industrial structure, especially the introduction and implementation of the "new normal" of the economy, which has changed the past high-speed economic growth model. This is also the reason for the slow growth of GDP and per capita GDP in various regions since 2017. Paying attention to internal adjustments, the transformation of promoting growth with development and promoting development with growth is conducive to improving the status quo of the "dual economic structure" and narrowing the regional economic gap [7]. In order to test whether there is absolute \( \beta \) convergence in the prefecture-level regional economic growth in Northwest China during the study period, this paper chooses per capita GDP as an indicator to measure regional economic development and uses the improved \( \beta \) convergence equation to calculate its convergence coefficient. The analysis results are shown in Table 1.

| Time period | Convergence rate | t     | Prob. | F test | Prob. | Half life cycle |
|-------------|------------------|-------|-------|--------|-------|----------------|
| 2017-2020   | 2.64             | -3.761| 0     | 14.144 | 0     | 26.6           |

The test results show that the t-test for the rate of convergence is 0, the regression coefficient passes the significance test, the F value is 0, and the significance of the entire equation also passes the test. It can be determined that there is absolute \( \beta \) convergence in this area during the study period. From 2017 to 2020, there is absolute \( \beta \) convergence between prefecture-level regions in Northwest China, and the
economic growth rate gap is approaching a convergence equilibrium at an annual rate of 2.64%. This speed is close to the conclusion of foreign scholars that the convergence speed is about 2%. This shows that the convergence of regional economic growth in the Northwest region during the study period is generally in line with the general situation of the regional economic growth convergence hypothesis. If the economic growth trend of the entire region remains unchanged in the future, it will take 26.6 years for the gap between the per capita GDP of the backward and developed regions to be reduced by half.

5. Conclusion
Based on the neoclassical economic convergence hypothesis, this paper uses beta convergence and spatial measurement models to analyse the economic growth convergence and its influencing factors in the five north western provinces, and draws the following conclusions and proposes suggestions for narrowing the regional gap and achieving balanced regional development. Due to changes in social and economic conditions and other uncertain factors, the benefit coefficient and supply constraint conditions of the objective function of the resource optimization allocation model will change accordingly. Therefore, the resource optimization allocation model needs to be revised in time to make the resource supply plan of various industries meet the needs of social and economic development.

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