Supplementary Materials

S1. The basic theory of grey relationship analysis

Grey system theory represents a new theory of engineering systems that was proposed by Ju-long Deng in 1982. The research object of grey system theory is an uncertain system characterized by poor information in which some information is known, while some information is unknown; this approach realizes an exact understanding of a system through the study of some known information. This theory presents a new analysis method known as relationship degree analysis, which is employed to measure the degree of association according to the degree of similarity or dissimilarity between factors. Because this analysis is performed based on the trend of development, the required sample size is not high, and there is no need to implement typical distribution rules in the analysis. At the same time, the main factors, the main features and the differences between the main factors can be extracted from the many factors that influence the system, and the quantitative results of the relationship degree can be consistent with the results of the qualitative analysis. Therefore, this method has a wide range of practicality.

S2. The calculation steps of grey relationship analysis

(1) Determine the reference sequences: $\{X_0(t)\}$ $t = 1,2 \cdots n$.

Determine the comparison sequences: $\{X_i(t)\}$ $i = 1,2 \cdots m;\ t = 1,2 \cdots n$.

(2) For dimensionless treatment, the initial value method is applied to the above sequences.

Initialization of the reference sequences:

$Y_0(t) = X_0(t)/X_0(1)$ $t = 1,2 \cdots n$.

Initialization of the comparison sequences:

$Y_i(t) = X_i(t)/X_i(1)$ $i = 1,2 \cdots m;\ t = 1,2 \cdots n$.

(3) Find the absolute difference between the sequences $\Delta_i(t)$:

$\Delta_i(t) = |Y_0(t) - Y_i(t)|$ $i = 1,2 \cdots m;\ t = 1,2 \cdots n$.

(4) Find the maximum difference (M) and the minimum difference (m):

M= $\max_i \max_t \Delta_i(t)$ m= $\min_i \min_t \Delta_i(t)$ $i = 1,2 \cdots m;\ t = 1,2 \cdots n$.

(5) Calculate the relationship coefficient $\xi_i(t)$:

$\xi_i(t) = \frac{\mathrm{m}+\rho\mathrm{M}}{\rho\mathrm{M}+\Delta_i(t)}$ $i = 1,2 \cdots m;\ t = 1,2 \cdots n$, where ρ is the coefficient of resolution, $\rho \in (0,1)$, which is usually 0.5.

(6) Calculate the grey relationship degree γ_i:

$$\gamma_i = \frac{1}{n}\sum_{t=1}^{n} \xi_i(t) \quad i = 1,2 \cdots m;\ t = 1,2 \cdots n.$$

where γ_i is the relationship degree between the comparison sequence X_i and the reference sequence X_0. The greater the value of γ_i is, the greater the degree of correlation between X_i and X_0.