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Exploring the Construction of a Grey Relational Analysis-Rank Correlation-Based Indicator System for Common Prosperity: A Case Study of Zhejiang Province

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Abstract: Common prosperity is an essential requirement of socialism. This paper examines the discourse on the proportion of the middle-income group and the research of scholars on common prosperity both domestically and internationally. A method for estimating the middle-income group, incorporating the consumer price index, is proposed, and the proportion of the middle-income group in Zhejiang Province over the past decade is calculated using the kernel density estimation method and included in the indicator pool. Relevant indicators are selected through grey relational analysis and rank correlation analysis, and a measurement system for the degree of achieving common prosperity is constructed, consisting of five primary indicators and twenty-five secondary sub-indicators. Taking Zhejiang Province as an example, the degree of achieving common prosperity and the implementation status of the five dimensions over the past decade are calculated. The results show that the scores of the five dimensions have shown a spiral upward trend in the past decade, but due to the impact of the epidemic, the overall degree of achieving common prosperity has declined after 2020.

Keywords: Construction of Indicator System; Grey Relational Analysis - Rank Correlation Analysis; Measurement of the Middle-Income Group.

1. Introduction

Common Prosperity is the further enrichment of China after achieving comprehensive well-off status, encompassing the coordinated prosperity of material life and spiritual civilization, the gradual enrichment from partial to overall, and the affluent development of high-quality economy, steady progress in people's livelihoods, improvement of living environment, and comprehensive development of economic, cultural, and social ecology. In June 2021, the Chinese government issued the "Opinions on Supporting the Construction of Demonstration Zones for Common Prosperity to Promote High-Quality Development in Zhejiang Province," designating Zhejiang Province as the first provincial exemplar of common prosperity in the country. It puts forward a series of major measures to guide the development direction. The realization of common prosperity in Zhejiang Province is divided into 7 main points and 52 sub-points, specifically covering the five major areas of politics, economy, culture, ecology, and society.

The proportion of the middle-income group is an important reference condition for achieving common prosperity in Zhejiang Province. During the research process, it was found that different scholars have diverse views on this indicator. The difficulty in measuring the middle-income group lies in defining its upper and lower limits. Research on this topic has been a hot issue in recent years, with scholars from various fields providing their insights and studies on this aspect.

Banerjee, Abhijit V. (2008) [1] measures the middle and lower-income groups based on per capita daily expenditure. Joseph G. Eisenhauer (2008) [2] argues that the concept of the middle class is ambiguous, as the government only provides standards for the poor without defining a lower limit for the middle class. Eisenhauer establishes clear boundaries between the rich and the poor, calculates the proportion of the population classified as rich or poor, and considers the remaining portion as the middle-class group. Luis F. López-Calva (2014) [3] introduces a new concept of the middle class based on poverty vulnerability. Using panel data, he determines the amount of comparable income, sets the lower threshold for the middle class, and measures the evolution of the middle-class size in countries such as Chile over the past two decades.

The research group of the National Development and Reform Commission's Macro Economic Research Institute (2005) [4] proposed the criteria for defining the middle-income group as follows: individual annual income ranging from 34,000 to 100,000-yuan, per capita disposable income of households ranging from 18,000 to 54,000 yuan, and annual household income ranging from 537,000 to 1.6 million yuan. These standards were among the earlier and more systematic ones officially introduced in China. Li Qiang (2017) [5] conducted comparative analysis with countries such as Japan and South Korea to propose three different standards, each with its advantages and disadvantages, for defining the middle-income group. Li Qiang also calculated the middle-income group in different regions of China, resulting in slight variations in the measurement outcomes. Liu Yulin and Xu Xinzhe (2017) [6], based on the China Family Panel Studies (CFPS) data, introduced the concept of per capita discretionary income of households as an indicator for defining the middle-income group. They used the kernel density estimation method to calculate the proportion of the middle-income group in China. Qiao Zhen (2022) [7] believes that under the conditions of socialism, production and distribution are unified, and it is essential to handle the relationship between the two. Qiao emphasizes the need for achieving internal unity between production and distribution

to realize common prosperity. Qiao also asserts that the proportion of the middle-income group directly reflects the management of income distribution.

The core of common prosperity lies in the concept of "shared prosperity." Scholars outside China do not have a specific concept of socialist common prosperity in China. Therefore, their research primarily focuses on the connection between income distribution, social fairness, and justice, exploring how to reduce income inequality and alleviate poverty. They propose similar concepts to the welfare society. Kang H. Park (1996) [8] examines the impact of education variables on income distribution using data from 56 countries. The study finds that higher levels of education have an equalizing effect on income distribution, and the dispersion of the labor force has a much greater impact on income equality compared to previous research findings. Meng (2020) [9], using the Musgrave Index (MT) and decomposing the Gini coefficient by total income sources, discovers that government transfer payments narrow the gap between individuals with unequal incomes. Even a small amount of transfer payments can lead to a decrease in the Gini coefficient, significantly contributing to the reduction of income inequality.

Yin Xiaoyuan (2022) [10] argues that common prosperity encompasses not only material wealth but also multiple dimensions such as politics, economy, culture, society, and ecology. Its ultimate goal is to achieve comprehensive human development and unity. The Implementation Plan for the Construction of High-Quality Development Demonstrative Zone for Common Prosperity in Zhejiang Province (2021) [11] emphasizes the acceleration of high-quality cultural development. It also proposes the construction of a national ecological civilization demonstration zone, promoting the leading demonstration of ecological civilization. Specific standards are implemented, including indicators such as air quality, water quality, and carbon emissions. Economic development is also an important part of achieving common prosperity.

Tong Menghua, Chu Cuicui, et al. (2022) [12], through empirical analysis using Kernel density estimation, Markov chains, and other methods, confirm that the differences in economic development mainly lie in regional disparities. Fu Caiwu and Gao Wei (2022) [13] analyze the differences and establish an evaluation system for the common prosperity of spiritual life, including two dimensions, four primary indicators, and seventeen secondary indicators. Cui Huiyu (2022) [14] believes that improving the economic level and enhancing the ecological environment are both goals pursued by common prosperity and necessary conditions for achieving it. The government should establish horizontal and vertical ecological compensation mechanisms. Huang Xinquan (2022) [15], based on the common prosperity of spiritual life, proposes three dimensions of value, including the connotation, significance, and developmental context of spiritual common prosperity, elucidating the profound significance of the value dimensions of spiritual life's common prosperity. Ke Yiwei (2022) [16] suggests that the concept of common prosperity has been endowed with more specific and profound connotations in the current era. The three dimensions of "developmental prosperity" at the production level, "shared prosperity" at the distribution level, and "sequential prosperity" in the process collectively constitute the core essence of understanding the concept of common prosperity in the new era.

In conclusion, it is observed that different scholars generally base their calculations of the middle-income group on income percentiles of residents. In this study, we incorporate the price index into the calculation of the middle-income group to better measure residents' living standards by eliminating the influence of purchasing power. Based on the actual situation, we determine the proportion of the middle-income group in Zhejiang Province over the years. This indicator data is then incorporated into the construction of a comprehensive evaluation index system in the subsequent sections. Regarding the research on common prosperity, most scholars have not provided a relatively unified indicator system. They have conducted studies on different aspects of common prosperity, with fewer studies that link different dimensions together. There are significant differences in the standards of their evaluation systems. Additionally, scholars have used inconsistent criteria for the proportion of the middle-income group, and there is no single appropriate indicator to measure the proportion of the middle-income group in Zhejiang Province. Therefore, this study utilizes CFPS data and introduces price variables to redefine the upper and lower limits of the middle-income group and calculate the proportion of the middle-income group. This approach aims to better measure residents' living standards by eliminating the influence of purchasing power and includes this indicator in the pool of indicators. Grey relational analysis and rank correlation analysis are used to select indicators, and entropy-based calculation using principal component analysis ensures the rationality of data selection. Finally, we construct a common prosperity indicator evaluation system using Zhejiang Province as an example.

2. Estimation of the Middle-Income Population

2.1. Principles of Estimating the Middle-Income Population

This paper utilizes the income data from the Income Section of the Chinese Family Panel Studies (CFPS) conducted by the Institute of Social Science Survey (ISSS). Consequently, the income distribution estimation necessitates the use of this dataset. Currently, the most widely used methods for function distribution estimation are parameter estimation and non-parameter estimation. Non-parameter estimation, in contrast to parameter estimation, does not require prior assumptions about the population distribution and yields more stable results with better fit under large sample sizes. Kernel density estimation, proposed by Rosenblatt, is the most extensively applied non-parameter estimation method. Hence, this paper employs non-parameter estimation for fitting purposes.

Kernel Density Estimation (Parzen Window) is a widely used non-parametric estimation method for estimating unknown density functions.

Kernel Function: Let there be n independent and identically distributed random variables: x_1 , x_2 , x_3 …… x_n ,with a probability density function f(x). The expression for estimating kernel density is as follows:

$$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x-x_i}{h}\right) \quad (1)$$

Where $\hat{f}(x)$ is the kernel density estimate of the population probability density $f(x)$, $K(\cdot)$ is the kernel function satisfying regularity and all properties of a

probability density function. There are multiple forms of kernel functions, and the choice of kernel function has minimal impact on the final estimation. In this study, we employ the Gaussian kernel, which is widely used in research. Its expression is as follows:

$$K(x) = \frac{1}{\sqrt{2\pi}} exp(-\frac{x^2}{2}) \quad (2)$$

In equation (1), h is a hyperparameter that controls the smoothness of the curve. The calculation formula for the optimal h [28] is as follows, according to previous research:

$$\hat{h} = \frac{4^{\frac{1}{5}}}{3}\sigma n^{-\frac{1}{5}} = 1.06\sigma n^{-\frac{1}{5}} \quad (3)$$

Where σ represents the sample standard deviation and n denotes the sample size.

The middle-income group encompasses not only individuals falling within a specific income range but also takes into account the actual living standards by linking income with prices. The level of consumption largely determines the standard of living. Therefore, this paper argues that the classification of the middle-income group should be based on a thorough consideration of living standards. Taking Zhejiang Province as an example and considering the high housing prices and cost of living, the income standards for the middle-income group in Zhejiang Province should be differentiated from the national standards. The influence of prices, which affects the standard of living, is incorporated into the calculation. This paper incorporates the impact of price fluctuations in Zhejiang Province on the standard of living into the formulation of standards, as outlined below:

$$Min = Min_c \times k \quad (4)$$

$$Max = Max_c \times k \quad (5)$$

$$k = \frac{CPI_i}{CPI_j} \quad (6)$$

Where k is the price impact index, calculated as shown in equation (6). CPI_j represents the current national Consumer Price Index, while CPI_i represents the current Consumer Price Index for Zhejiang Province. Both indices are based on a 1980 price index with a base of 100. Min denotes the lower bound of the middle-income classification standard, while Min_c and Max_c are the commonly used lower and upper bounds of middle-income defined by academic circles and the National Bureau of Statistics. In this study, Max_c and Min_c are defined based on the standards proposed by Alan Krueger, Chairman of the White House Council of Economic Advisers, using 0.5 and 1.5 times the median income level as the thresholds. This method is widely accepted by international research institutions and experts. Max represents the upper bound of the middle-income classification standard. By replacing the previously used indicators with the revised upper and lower bounds of middle-income, it is possible to address the issue of varying consumption levels and price differences among provinces, thus avoiding differences in living standards caused by higher income associated with higher consumption.

2.2. Estimation of the Middle-Income Population in Zhejiang Province

This study utilizes data from the China Family Panel Studies (CFPS) by extracting the income column data specifically for Zhejiang Province. Missing values and values that do not meet the specified conditions are removed. The income data from 2012 to 2020 are then used to visualize the income distribution of Zhejiang Province residents using kernel density estimation, as depicted in Figure 1:

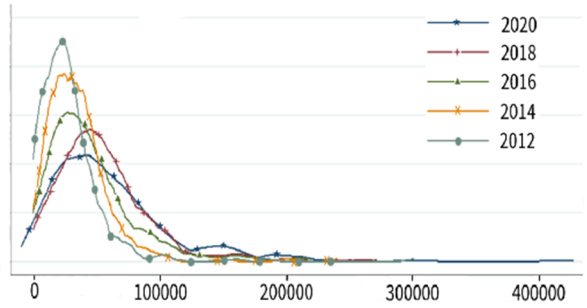


Figure 1. Kernel Density Estimation of Income Distribution in Zhejiang Province (2012-2020)
Data Source: Calculated from CFPS Dataset

From the above figure, it can be observed that the high-income population in Zhejiang Province shows a gradual upward trend over time. Although there were noticeable peaks and a more concentrated income distribution before 2016, the peaks become less prominent after 2018, and the distribution becomes relatively more dispersed compared to previous years. This indicates that Zhejiang Province has witnessed reasonable improvements in income distribution in the later years, with a significant increase in the middle-income group. Despite the improvement in income structure, income inequality still exists among the people of Zhejiang Province.

Based on the CFPS data from 2012 to 2020, the overall probability density was estimated using kernel density estimation. The proportion of the middle-income population in Zhejiang Province was then calculated using the adjusted middle-income standard. For the years with missing data, the proportion of the middle-income group was estimated using extrapolation based on the observed trend. The resulting curve is depicted below:

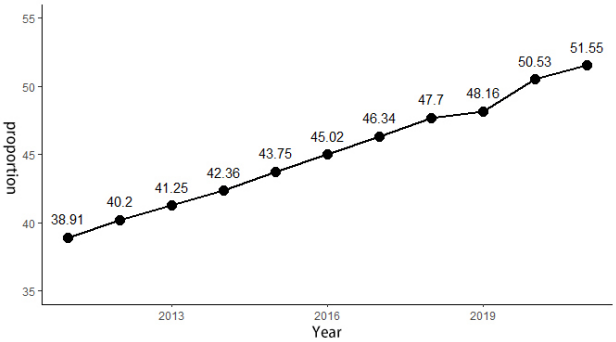


Figure 2. Trend of the Proportion of the Middle-Income Population in Zhejiang Province
Data Source: Calculated from CFPS Dataset

Since 2012, the proportion of the middle-income population in Zhejiang Province has steadily increased, indicating significant progress towards achieving the important indicator of shared prosperity.

3. Construction of an Indicator System for Building Shared Prosperity

3.1. Indicator Selection

Shared prosperity represents comprehensive wealth, encompassing economic, ecological, and cultural aspects. Referring to Wang Lu's [16] methodology for selecting

indicator systems in comprehensive evaluations and considering the relevant aspects of shared prosperity mentioned in the "Implementation Plan for Shared Prosperity in Zhejiang Province," this study refines the indicator system for shared prosperity in Zhejiang Province into five dimensions for assessing the degree of implementation. Five secondary indicators are established, namely: high-quality development pattern (HDP), income distribution (ID), people's livelihood, ecological civilization construction (ECC), and spiritual civilization construction (SCC). These dimensions are utilized to establish indicators for monitoring and evaluating the progress of shared prosperity development in Zhejiang Province. Through a selection process that involves screening relevant indicators, including incorporating the previously calculated indicator for the proportion of the middle-income group into the indicator pool, the study initially employs gray relational analysis to eliminate indicators with low correlation compared to the overall threshold. Subsequently, rank correlation analysis is utilized for a second round of screening. Finally, through an information entropy comparison, the selected indicators are verified to meet the information requirements of the indicator system in this study. With the premise of prioritizing comprehensiveness and representativeness, various comprehensive indicators mentioned in relevant studies are collected for each of the five dimensions to reflect the overall attributes of the evaluated subjects. These indicators are then subjected to individual screening, and the combined indicators from each subcategory within the dimensions are integrated to form an ideal comprehensive indicator evaluation system.

3.2. Achieving Comprehensiveness in Indicators

By referencing the definition and connotation of shared prosperity and drawing from relevant studies on high-quality economic development by Su Limin (2022) [17], Tong Menghua and Chu Xiaoxiao (2022) [18], as well as research on income distribution and rural revitalization from Yin Xiaoyuan (2022) [10], Yu Jianxing (2022) [19], a selection of indicators for the economic dimension was made. The selection of indicators for the livelihood dimension and ecological civilization construction dimension was based on the research on livelihood and green China's indicator systems conducted by Ke Yiwei and Zhang Zhen (2022) [15], Cui Huiyu (2022) [13], and Qi Yue (2018) [20]. In the dimension of spiritual civilization construction, indicator selection was informed by the studies of Li Jinchang and Yu Wei (2022) [21], Fu Caiwu (2022) [12], Yuan Yongke (2019) [22], and Li Changda (2019) [23]. Incomplete indicators were excluded due to data gaps and controversies. A three-level hierarchical structure model was constructed, with the top level representing the shared prosperity indicators, the second level consisting of five secondary indicators, and the final level containing 37 tertiary indicators. Data were obtained from the National Bureau of Statistics, Provincial Statistics Bureau, and the ISSS database. The main indicators established based on the five secondary indicators are shown in the table below:

The high-quality development pattern (HDP) dimension measures the level of economic development in Zhejiang Province, residents' income level, innovation capacity, and degree of openness, starting from economic benefits. It reflects whether the economic volume of Zhejiang Province is growing and whether the economic development environment is healthy. GDP and per capita GDP reflect the residents' living standards, total import and export volume demonstrate Zhejiang Province's degree of international exchange, and research funding and patents reflect Zhejiang Province's innovation-driven capacity.

Table 1. High-Quality Development Pattern Dimension

Dimension	Indicator Name	Indicator Direction
High-Quality Development Pattern	GDP	Positive
	R&D Expenditure as a Percentage of GDP	Moderate
	Per Capita Granted Patents	Positive
	Final Consumption Rate	Moderate
	Per Capita Disposable Income (in CNY)	Positive
	Total Import and Export Volume as a Percentage of GDP	Moderate
	Per Capita GDP (in ten thousand CNY)	Positive
	Labor Productivity per Worker	Positive
	Contribution of Resident Consumption	Positive

Among them, 'Positive' indicates positive indicators, 'Moderate' indicates moderate indicators with a value range, 'Inverse' indicates inverse indicators. The same applies to the table below.

In the income distribution (ID) aspect, indicators such as income Gini coefficient and the proportion of middle-income group are set to primarily reflect the degree of "shared" prosperity and measure the level of coordination and balance in Zhejiang Province's development. These indicators play a crucial role in achieving shared prosperity.

Table 2. Income Distribution Dimension

Dimension	Indicator Name	Indicator Direction
Income Distribution	Urban-Rural Income Gap	Inverse
	Regional Income Disparity	Inverse
	Proportion of Middle-Income Group	Positive
	Regional Development Disparity	Inverse
	Per Capita Disposable Income	Positive
	Proportion of GDP from Tertiary Sector	Positive

In terms of livelihood, the description mainly focuses on three aspects: healthcare bed capacity, education, and housing. These three aspects are the most frequently mentioned indicators in the livelihood dimension and can accurately measure the development of livelihood. The number of healthcare beds is an important component in establishing a comprehensive and integrated healthcare service system and promoting the orderly construction of healthcare infrastructure. Education is the foundation of livelihood, as the intelligence of the youth contributes to the intelligence of the nation. Higher education plays a particularly crucial role in the development of a country, especially in the advancement of high-end technologies. Employment is the foundation of livelihood and has a significant impact on social

stability.

Table 3. Livelihood Dimension

Dimension	Indicator Name	Indicator Direction
Livelihood	Beds per 1,000 Population	Positive
	Education Expenditure/GDP	Moderate
	Gross Enrollment Ratio in Higher Education	Positive
	Urban Unemployment Rate	Inverse
	Per Capita Housing Area	Positive
	Area of Public Cultural Facilities per 10,000 People	Positive
	Urbanization Rate	Positive
	Railway Mileage per 10,000 Square Kilometers	Positive
	Number of Physicians per 1,000 Population	Positive
	Housing Price/Per Capita Disposable Income	Inverse

In terms of ecology, following the principle of promoting high-level modernization that promotes harmonious coexistence between humans and nature, an ecological civilization stronghold is being developed. Specific requirements have been set for air quality, water quality, and carbon emissions. The implementation plan for common prosperity also emphasizes the implementation of strict ecological environmental protection systems and the continued promotion of regional coordinated governance of various pollutants. Therefore, the main indicators selected are air quality, water quality, and carbon emissions.

Table 4. Ecological Civilization Construction

Dimension	Indicator Name	Indicator Direction
Ecological Civilization Construction	Air Quality Index (Proportion of Excellent and Good Days)	Positive
	PM2.5 Concentration (mg/m³)	Inverse
	Compliance Rate of Water Quality (Level III or above)	Positive
	Carbon Emission Intensity (per unit of GDP)	Inverse
	Energy Consumption Intensity (tons per 10,000 yuan of GDP))	Inverse
	Forest Coverage Rate	Positive

In terms of spiritual civilization, the cultural industry is an emerging and promising industry that represents a unique cultural form and economic form. It includes literary and artistic creation, photography, dance, and other forms of artistic expression, providing a source of spiritual enjoyment for people when their basic living conditions are met. The value of this industry can significantly reflect the improvement in the quality of life for residents.

The physical fitness qualification rate of the population is an indicator that measures the health status of the residents. Only when basic living conditions are met, people have time to exercise and engage in health management. Similar to the cultural industry, it indirectly reflects the quality of life for residents.

Table 5. Spiritual Civilization Construction

Dimension	Indicator Name	Indicator Direction
Spiritual Civilization Construction	Cultural Industry Value as a Percentage of GDP	Moderate
	National Comprehensive Physical Fitness Qualification Rate	Positive
	Per Capita Sports Venue Area	Positive
	Public Cultural Expenditure	Positive
	Proportion of Population Engaging in Regular Physical Exercise (including students)	Positive
	Tourism Participation Rate	Positive

3.3. Achievement of Indicator Representativeness

Gray relational analysis is particularly suitable for constructing comprehensive evaluations when the sample space is small and the relationships between indicators are not clear. By setting thresholds in each dimension, the gray relational degree of each dimension is calculated using each sequence within that dimension as the threshold. The correlation results of the first dimension are listed in Table (6), while the same calculation method is applied to obtain the correlation matrix for the remaining dimensions. A higher gray relational degree indicates a richer amount of information. Based on the sum of correlation degrees in the matrix, indicators within a dimension that have lower correlation degrees compared to the average are removed, while indicators with higher correlation degrees compared to the average are retained.

Filtering Steps:

(1) Non-dimensionalization is performed on the data, and the specific method is as follows: Divide each element in each column of the indicator by the mean of that column. This can eliminate the influence caused by different magnitudes.

(2) Calculate the correlation coefficient between each comparison sequence and the reference sequence. The reference sequence is each sequence within each dimension. The specific calculation formula is as follows:

$$\zeta_i(k) = \frac{\triangle min + \rho \triangle max}{\triangle_{ik} + \rho \triangle max} \quad (7)$$

$$\triangle_{ik} = |x_0(k) - x_i(k)| \quad (8)$$

Where $\triangle min$ is the minimum absolute value between the reference sequence and the compared sequence within the dimension, and $\triangle max$ is the maximum absolute value between the reference sequence and the compared sequence within the dimension. ρ is the resolution coefficient, usually taken as 0.5.

(3) Calculate the relevance degree of each element with respect to the reference sequence and calculate the mean value. Delete the indicators that are less than the mean relevance degree. The specific formula is as follows, and the resulting relevance degree matrix for Dimension 1 is shown in Table (6).

$$\rho_{0i} = \frac{1}{m} \sum_{k=1}^{m} \zeta_i(k) \quad (9)$$

The relevance degree tables for the remaining dimensions can be obtained following the above steps 1-3. According to the determination principle described above, the final number of indicators for the 5 dimensions obtained is 29, Table 8 displays the 25 indicators included in it

Table 6. Grey Correlation Coefficients for the First Dimension

Indicator	GDP	R&D Expenditure Ratio	...	Consumption Contribution Rate
GDP	1	0.848	……	0.635
R&D Expenditure Ratio	0.848	1	……	0.664
...	……	……	1	……
Consumption Contribution Rate	0.635	0.664	……	1

Source of Data: Calculated by the Authors

3.4. Reasonableness of Data and Assurance of Information Content

1.Further Selection of Indicators Using Spearman Rank Correlation Coefficient

Since the indicators selected through grey correlation analysis do not consider the potential issue of multicollinearity among the indicators, this step employs the method of Spearman rank correlation analysis to pairwise screen the indicators with information collinearity and eliminate those with lower grey correlation degrees. The basic formula for calculating the Spearman rank correlation coefficient is as follows:

$$\rho_s = 1 - \frac{6\sum(d_i)^2}{n(n^2-1)} \quad (10)$$

The threshold for the Spearman rank correlation coefficient in mainstream literature is generally set at 0.9. The main reason for this is that the chosen value falls within a reasonable range. If the threshold value is set too high, it would increase the difficulty of data reduction, while setting it too low may result in the erroneous removal of some valid indicators, thus affecting the establishment of the final indicator system for common prosperity. Through this round of screening, the final 25 indicators are selected and included in the construction process of the final indicator system for common prosperity, along with their corresponding weights, as summarized in Table (8).

2.Calculation of Information Content and Rationality in Indicator System

(1) Principle of Determination

The principle of determination is based on the evaluation model of information contribution using the principal component-entropy proposed by Chi et al. [24]. It aims to determine the proportion of information contained in the selected data compared to the initial comprehensive data. Firstly, the information content of the selected indicators is calculated, followed by the calculation of the information content of the comprehensive indicators. Finally, the ratio of these two information contents is used to measure the rationality of the indicator selection in this study. If the ratio exceeds 90%, it indicates that the indicator selection in this study is considered reasonable.

(2) Decision Step

Step 1: Principal Component Transformation

The indicator data is subjected to principal component transformation to obtain a set of new variables F_1, F_2, ..., F_m (m≤p), where m represents the number of principal components. The selection of m is based on the principle of cumulative contribution rate of 100% in principal component analysis.

Step 2: Scoring of Principal Component Data

The principal component data, f_ij, is scored to obtain the scoring value z_ij. The scoring formula is as follows:

$$z_{ij} = \frac{f_{ij} - min(f_{1j},\cdots,f_{nj})}{max(f_{1j},\cdots,f_{nj}) - min(f_{1j},\cdots,f_{nj})} \quad (11)$$

Step 3: Calculation of Information Content in Indicator Data

The calculation formula for determining the information content contained in the indicator data is as follows:

$$I(X_1 \ldots X_p) = \sum[Ln(n) - (-\sum_{i=1}^{n} z_{ij} \frac{1}{\sum_{i=1}^{n} z_{ij}} ln \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}})] \quad (12)$$

Simultaneously, the aforementioned calculation process can be repeated for the finally selected indicators to obtain their corresponding information contribution. By applying the three steps to both the initial comprehensive set of 37 indicators and the final set of 25 selected indicators, the final information contribution rates exceeded 98%, surpassing the critical threshold of 90%. With 67.6% of the data reflecting 98% of the information content, the dimension reduction is considered reasonable, thus proceeding to the next phase of analysis.

3.5. Data Preprocessing:

The Critic method is a superior objective weighting method compared to the Entropy Weight method and Standard Deviation Weight method. It comprehensively evaluates the objective weights of indicators based on the comparative intensity and conflicts among evaluation indicators. The weighting determination of the indicator system in this paper is based on the Critic method. The first step of the Critic method is to perform dimensionless processing on the data. There are various methods for dimensionless processing, and this paper employs the following three methods for three different types of indicators:

Table 7. Normalization Summary

Category	Scaled Feature	Conditions
Positive Normalization	$x' = \frac{x - min(x)}{max(x) - min(x)}$	Positive
Reverse Normalization	$x' = \frac{max(x) - x}{max(x) - min(x)}$	Inverse
Mean Normalization	$\frac{1}{\lvert x_i - X \rvert + t}$	Moderate indicators, if the target value is an interval, X is taken as the median. t is an adjustment parameter that ensures the processed data remains within the same dimension.

3.6. Weight Determination

The indicator system established in this study consists of five major dimensions. Due to the commonality of common prosperity, the weight of each dimension in the overall system is determined by the number of indicators within that dimension. The weight of a dimension is calculated as the proportion of the number of indicators in that dimension to the total number of indicators. As mentioned earlier, the Critic method is based on the conflict and comparative intensity of indicators to comprehensively measure the weights of indicators. The performance indicators for these aspects are indicator variability and indicator conflict.

(1) Indicator Variability, Expressed in Standard Deviation:

$$\overline{x_j} = \frac{1}{n}\sum_{i=1}^{n} x_{ij} \quad (13)$$

$$S_j = \sqrt{\frac{\sum_{i=1}^{n}(x^{ij}-x^j)^2}{n-1}} \quad (14)$$

Where S_j represents the standard deviation of the j-th indicator, the CRITIC method utilizes the standard deviation to represent the fluctuation of values within each indicator. A larger standard deviation indicates greater variability in the values of the indicator, reflecting more information and indicating a stronger evaluative strength for the indicator. Therefore, more weight should be assigned to this indicator.

(2) Indicator Conflict, Expressed in Correlation Coefficients:

$$R_j = \sum(1 - r_{ij}) \quad (15)$$

Where r_{ij} represents the correlation coefficient between evaluation indicators i and j, the correlation coefficient is used to measure the correlation between indicators. The stronger the correlation with other indicators, the less conflicting the indicator is with others. This indicates a higher degree of information redundancy and reduces the evaluative strength of the indicator to some extent. Therefore, the weight assigned to this indicator should be reduced.

(3) Information Content and Objective Weight

The information content is a combination of indicator conflict and variability.

$$C_j = S_j \sum_{i=1}^{p}(1 - r_{ij}) = S_j \times R_j \quad (16)$$

The larger C_j, the greater the influence of the j-th evaluation indicator in the entire evaluation indicator system, and it should be assigned a higher weight.

Therefore, based on the above, the objective weight W_j of the j-th indicator is calculated as follows:

$$W_j = \frac{C_j}{\sum_{j=1}^{p} C_j} \quad (17)$$

Since the number of indicators varies in the five dimensions, the weight calculation is performed separately for each dimension. In this study, which focuses on the construction of an indicator system for common prosperity, the weight of each dimension is determined by the number of indicators in that dimension. The weight of each dimension is obtained by dividing the number of indicators in that dimension by the total number of indicators. The specific calculation formula is as follows:

$$W_p = \frac{n_p}{N} \quad (18)$$

Where n_p represents the number of indicators in the P-th dimension, and N is the total number of indicators. The critic method is used to calculate the weights of indicators within each dimension. Then, the indicator weights are multiplied by the dimension weights to obtain the overall indicator weights. The weights of each indicator, along with the calculated total weights using the aforementioned method, are filled into Table 8.

Table 8. Weight Summary of the Common Prosperity Indicator System

Primary Indicator	Secondary Indicator (Dimension)	Tertiary Indicator (Name)	Dimension Weight (%)	Weight within Dimension (%)	Total Weight (%)
Common Prosperity	High-Quality Development Pattern	GDP	28	7.54	2.11
		R&D Expenditure as a Percentage		5.75	1.61
		Number of Patents Granted		27.77	7.78
		Per Capita Disposable Income (in CNY)		7.95	2.23
		Per Capita GDP (in ten thousand CNY)		7.33	2.05
		Labor Productivity		8.24	2.31
		Labor Compensation as a Percentage of GDP		35.45	9.93
	Income Distribution	Income Distribution Urban-Rural Income Disparity	16	12.91	2.07
		Middle-Income Group		19.71	3.15
		Regional Development Disparity Coefficient		54.7	8.75
		Percentage of GDP from the Tertiary Industry		12.68	2.03
	Livelihood	Livelihood Number of Hospital Beds per Thousand People	24	10.79	2.59
		Education Expenditure as a Percentage of GDP		13.95	3.35
		Gross Enrollment Ratio in Higher Education		6.02	1.44
		Urban Unemployment Rate		48.89	11.73
		Railway Length per Unit Area		8.8	2.11
		Number of Physicians per Thousand People		11.55	2.77
	Ecological Civilization Construction	Ecological Civilization Construction Air Quality Index (Proportion of Excellent Days)	20	17.74	3.55
		PM2.5 Concentration (mg/m³)		34.6	6.92
		Percentage of Class III or Higher Water Quality		20.27	4.05
		Carbon Emission per Unit of GDP		27.39	5.48
		Forest Coverage		0	0
	Spiritual Civilization Construction	Spiritual Civilization Construction Cultural Industry Value as a Percentage of GDP	12	63.77	7.65
		National Comprehensive Physical Fitness Qualification Rate		12.11	1.45
		Number of People Regularly Engaging in Physical Exercise (Including Students) as a Percentage of the Total Population		24.12	2.89

Data Source - Author's Calculation

4. Measurement of the Degree of Achieving Common Prosperity

The main purpose of this paper is to establish an indicator system for achieving common prosperity in Zhejiang Province and measure the degree of achieving common prosperity in the province. By formulating the implementation plan for common prosperity in Zhejiang Province and setting the target values for each indicator based on the goals proposed in the 15th Party Congress of Zhejiang Province, the current values are calculated. The calculated values are then normalized using the method described earlier

to obtain processed data, denoted as z_i. If the current value exceeds the set target value, the score z_i is assigned as 1. After obtaining the scores, the degree of achievement can be calculated based on the previously determined weights and scores, using the following basic calculation formula: $Z = \sum w_i z_i$. The degree of achievement for a specific dimension can be calculated based on its weighted score.

4.1. Measurement Results of the Degree of Achieving Common Prosperity in Each Dimension

This section primarily discusses the degree of achieving common prosperity in each dimension in Zhejiang Province. By calculating the weighted average of the scores obtained for each dimension and dividing it by the total weight, the specific score for a particular dimension can be obtained. The specific method is as follows:

$$z_i = (\sum z_{ij} \times w_{ij}) \div \sum w_{ij} \quad (19)$$

where z_i represents the score for the dimension under consideration, and w_ij represents the weights of individual indicators within the dimension.

The line graph illustrating the scores for each dimension is shown in Figure (3).

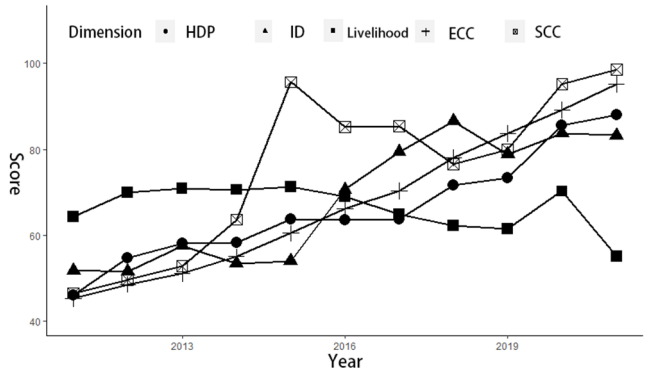


Figure 3. Trend of Scores for the Five Dimensions in Zhejiang Province
Data Source: Author's Compilation

The specific meanings of the abbreviations in Figure 3
HDP: High-quality Development Pattern.
ID: Income Distribution.
ECC: Ecological Civilization Construction.
SCC: Spiritual Civilization Construction.

Based on the results, the score for the construction of spiritual civilization in Zhejiang Province has consistently remained high, and in most years, it has been higher than the other four dimensions. This demonstrates that Zhejiang Province has achieved a high level of completion in cultural propaganda and is approaching the level mentioned in the implementation plan for common prosperity. The score for income distribution has shown a spiral growth trend from 2011 to 2021, which is attributed to Zhejiang Province's ongoing economic transformation and an increased proportion of secondary distribution. With the continuous improvement of the environment and the increase in people's income, the score for people's livelihood has remained relatively stable. It can be clearly observed from the graph that after 2019, the scores for people's livelihood and ecological civilization construction have risen simultaneously. However, there was a slight decline in the score for people's livelihood in 2020, primarily due to a significant increase in urban unemployment rate caused by the COVID-19 pandemic. As the impact of the pandemic gradually diminishes, the score for people's livelihood will quickly return to the right track.

The improvement of the ecological environment has significantly enhanced people's satisfaction with their lives, and Zhejiang Province has consistently adhered to the concept that "green waters and green mountains are as valuable as mountains of gold and silver," placing ecological environment governance in a prominent position. The growth trend of the score for the dimension of high-quality development pattern has experienced a slowdown followed by growth over the past decade, with an overall stable upward trend. The shortcomings of Zhejiang Province in economic development are reflected in the lack of natural resources, including water resources, arable land resources, and forest resources. This to some extent affects Zhejiang Province's economic model. Currently, Zhejiang Province's economic structure is primarily focused on light industry, with the secondary and tertiary sectors as the pillars of the province's industries. Efforts are being made towards economic transformation, the development of a modern economic system, and the establishment of an information-based economy with the Internet at its core, which will become a top priority for Zhejiang's economy. The province is shifting from an investment-driven approach to a technology-driven one. Despite a temporary slowdown in development due to the impact of the COVID-19 pandemic in 2020, Zhejiang Province will maintain high-speed and stable growth after the necessary adjustments are made.

4.2. Measurement of the Degree of Achieving Common Prosperity in Zhejiang Province

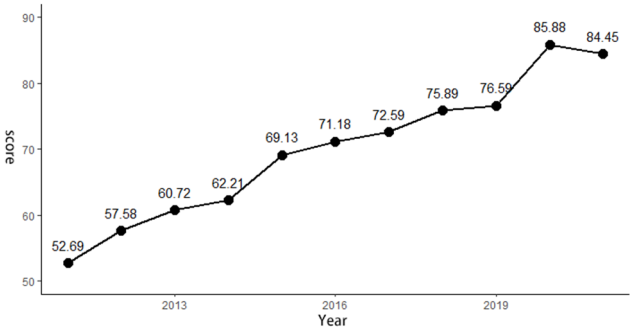


Figure 4. Score of Zhejiang Province's Achievement in the Implementation of Common Prosperity
Data Source: Author's Compilation

In this study, the weights of each indicator were ultimately determined using the critic method. Taking Zhejiang Province as an example, the degree of achieving common prosperity in the province from 2011 to 2021 was actually measured. The specific results are shown in Figure (4). The selection of indicators in this paper was based on the implementation plan for common prosperity in Zhejiang Province, the report of the 15th Party Congress of Zhejiang Province, and relevant studies conducted by experts in corresponding fields. However, there may be some discrepancies with the actual situation. Additionally, the data used in this paper were obtained from the National Bureau of Statistics, the Zhejiang Provincial Bureau of Statistics, and the ISSS Data Center (CFPS data), which may result in some data gaps. Among them, missing data for certain indicators for no more than three years were supplemented using trend extrapolation methods, including the calculation indicators for final consumption rate, number of elderly care beds, national

physical fitness qualification rate, and the middle-income group.

According to the calculation results, the index of achieving common prosperity in Zhejiang Province has shown a continuous upward trend, rising from 52.69 points in 2011 to 84.45 points in 2021. The development of Zhejiang Province in the past decade is evident. Among the 25 indicators included in this study, 5 indicators have already reached or exceeded the target values. These indicators are per capita patent authorization quantity, per capita bed capacity, per capita housing area, PM2.5 concentration, and the rate of water quality meeting Class III or above standards. Additionally, 12 indicators have achieved scores above 80 points. In particular, the PM2.5 concentration increased from 35 points in 2011 to 100 points in 2020 and remained at that level in 2021. The water quality compliance rate has also been consistently high since 2017, indicating that Zhejiang Province's ecological environment far surpasses the national average level.

However, the construction of common prosperity in Zhejiang Province faced some obstacles and experienced a slight decline after 2020 due to the impact of the pandemic. Nevertheless, with policy adjustments and the recovery of public confidence, the process of common prosperity is expected to quickly return to the right track.

In terms of economic development, the total GDP is still a certain distance away from the target value, indicating room for improvement. Indicators related to per capita GDP and the direction of economic aggregate generally scored lower than other indicators, but they have shown relatively rapid progress and high annual growth rates. The goal of achieving common prosperity by 2035 is steadily advancing.

It is worth noting that the score for controlling the unemployment rate decreased from 82.6 points in 2020 to 47.6 points in 2021. Zhejiang Province has a large number of small and medium-sized enterprises, and they were severely affected by the pandemic, resulting in numerous bankruptcies and closures. Additionally, the influx of many college graduates into the job market has made it difficult for them to find employment, leading to an increase in the unemployment rate. The unemployment rate is an important factor in maintaining social stability and is a prominent issue of concern. Therefore, Zhejiang Province needs to pay sufficient attention to this matter.

5. Conclusion and Outlook

This paper establishes an index system to measure the level of common prosperity based on the connotation of common prosperity and the implementation plan in Zhejiang Province. Firstly, by extensively referring to relevant domestic and foreign literature, the paper defines the standard for the national middle-income group as 0.5 to 1.5 times the median income of domestic residents. The upper and lower limits of this standard are adjusted using a price index factor, denoted as K. The data from the Zhejiang section of the China Family Panel Studies (CFPS) is utilized to estimate the kernel density of the income group in Zhejiang Province. By incorporating the adjusted upper and lower limits, the proportion of the middle-income group in Zhejiang Province is determined. This adjustment method effectively prevents differences in living standards due to changes in price levels for individuals with the same income.

The construction of the index system for common prosperity in this paper selects a total of 47 indicators across five dimensions. Through grey correlation analysis and rank correlation information entropy analysis, 25 final indicators are selected. Preprocessing of data for indicators with different natures is performed using three normalization methods. Subsequently, the weights of each indicator are determined using the critic method. The scores of each standardized indicator are weighted to obtain the scores for the five dimensions over the past decade, thereby measuring the level of common prosperity in these dimensions. Finally, by aggregating all the indicators with weights, the overall level of common prosperity in Zhejiang Province is calculated. The results indicate that the score for common prosperity in Zhejiang Province exceeded 80 points after 2019, marking an important step towards achieving common prosperity. From the scores of the five dimensions, it can be observed that ecological civilization construction, income distribution, and the pattern of high-quality development consistently maintain high scores, reflecting a higher sense of happiness and satisfaction among the people of Zhejiang Province. The growth of the score for ecological civilization construction is the most stable and fastest among the five dimensions, demonstrating that the people of Zhejiang Province are consistently practicing the concept of "Lucid waters and lush mountains are invaluable assets." The score for the dimension of high-quality development is relatively lower, which is related to the higher target of common prosperity. However, the economic development has been relatively stable, and the economic situation in Zhejiang Province is favorable, providing sufficient time to achieve the desired goals within the target period.

Based on the above conclusions, the following suggestions are proposed: (1) Common prosperity is an exploration undertaken by China under the establishment of socialism with Chinese characteristics in the new era. There is no experience to draw upon from previous historical stages, which has both advantages of being free from the influence of other ideologies and obvious disadvantages, making it prone to various problems. Therefore, it is important to be cautious from the beginning. It is necessary to promptly identify the causes of problems and find timely solutions when problems arise. (2) Since the outbreak of the pandemic, the level of common prosperity in Zhejiang Province has declined to some extent. It is important to strengthen the resilience of cities and even the entire province, in order to have sufficient means and methods to respond in case of another emergency. For example, Zhejiang Province is prone to floods, and at the provincial level, efforts should be made to establish joint prevention and control mechanisms among urban clusters and learn from advanced experiences in flood control. Precautionary and warning measures should be well implemented to issue the fastest possible warning when emergencies occur. (3) It is necessary to accelerate the construction of livelihood safeguards and improve the happiness and satisfaction of the people. The analysis results indicate that the score for livelihood is greatly affected by the pandemic, indicating insufficient resilience. Therefore, while comprehensively developing the economy and protecting the environment, efforts should also be made to achieve synchronized development in livelihood. Ensuring a stable employment environment, enhancing the capacity to cope with major risks, strengthening and improving infrastructure construction, increasing hospital beds, and ensuring timely response during major public health events such as the COVID-19 pandemic should be prioritized.

In the five dimensions of high-quality development pattern, income distribution, livelihood, spiritual civilization construction, and ecological civilization construction mentioned in this paper, there are still many details and calculation methods that require more systematic and in-depth discussions. The analysis and construction of the index system for the middle-income group and common prosperity in Zhejiang Province may overlook some aspects that should have been considered. The purpose of this paper is to establish a preliminary index system for common prosperity, providing a reference for the construction of common prosperity in Zhejiang Province, and offering suggestions for further research.

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