



Sustainable Development Analysis of International Trade in Forest Products Based on Fuzzy Comprehensive Evaluation

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SUMMARY: *This study employs the Fuzzy Comprehensive Evaluation Method to establish an assessment framework for the sustainable development capacity of China's forest product international trade. By integrating the Entropy Weighting Method, it measures and analyzes the sustainable development level of China's forest product trade from 2015 to 2024 across three dimensions: economic benefits, social benefits, and environmental and ecological benefits. The results indicate that China's sustainable development capacity in forest product trade has shown a significant upward trend, with the relative proximity index increasing significantly from 0.2751 in 2015 to 0.6583 in 2024. The growth rate of the comprehensive score was relatively small from 2015 to 2022, while it increased significantly from 2022 to 2024, rising from 0.5528 in 2022 to 0.6583 in 2024, with an average annual growth rate of 19.08%. Regional development imbalances are prominent, with the comprehensive evaluation value of the eastern region (0.7084) significantly higher than that of the central (0.6436) and western regions (0.5551).*

KEYWORDS: *international trade in forest products; sustainable development capacity; fuzzy comprehensive evaluation; entropy weight method*

1 Introduction

International trade is the exchange of goods, services, and technologies between nations, serving as a bridge linking regional sustainable development with global sustainable development. However, international trade has evolved beyond its original simple form of barter and now involves the exchange of ecological capital and ecological environmental space [1, 2]. In recent years, in order to respond to global climate change and achieve resource and environmental protection, the impact of international trade on the ecological environment has received great attention from countries around the world. While focusing on the economic benefits brought by trade, many countries have also begun to focus on the ecological sustainability of trade. Relevant international organizations and countries have established environmental protection and management departments and established policies and legal systems related to the ecological environment, such as the Lacey Act in the United States and the Timber Act in the European Union [3-7].

Global forest product trade encompasses multiple sub-sectors including timber, pulp, paper, and furniture, with massive and continuously growing international trade volumes. According to statistical data, the global trade value of timber and wood products has increased by approximately 50% over the past decade, while pulp and paper trade value has grown by

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approximately 30% [8, 9]. Wang et al. [10] pointed out that the main trading countries in the global forest products trade include the United States, China, and Germany, among others. These countries have high GDPs, and when combined with abundant labor and capital resources, they become major importers of raw forest products and major exporters of processed forest products. Meanwhile, countries with abundant forest resources are major exporters of raw forest products. Global forest product trade has always been an important component of the global economy, playing a crucial role in the economic growth and sustainable development of countries. Economic growth has driven global demand for forest products, promoting trade development. Meanwhile, the energy crisis and heightened environmental awareness have increased countries' reliance on renewable resources, further boosting demand for forest products [11-14]. Mi et al. [15] used an autoregressive distributed lag model to analyze the relationship between forest product trade and national sustainable development in China and the United States, finding that forest product trade contributes to the long-term and short-term sustainable development of both countries.

However, the timber resources required for international trade in forest products are sourced from forests, which are a vital resource foundation for human survival and development. International trade in forest products that disregards ecological and environmental costs can cause devastating destruction to global forest resources, posing a serious threat to human survival and development, while also constraining the sustainability of forest products [16-19]. Rawat and Tekleyohannes [20] mentioned that Ethiopia is projected to reach a wood consumption of 158 million cubic meters for primary and secondary forest products by 2033. Given this staggering consumption rate and the current state of forest product industry development, they emphasized that the balanced development of forest resource production and ecology is a crucial direction for the sustainable development and innovation of forest products. Tian et al. [21] used the entropy method to analyze the green level of China's wood-based forest product trade. Chemical pulp and sawn timber trade are at a high level, while particleboard, corrugated cardboard, newsprint, cardboard boxes, and packaging paper trade are at a medium level. Medium-density fiberboard and plywood trade are at a lower level, with prominent pollution issues during product manufacturing. Relevant policies, technical support, and measures to promote the export rate of high-value-added products are needed. Sohail et al. [22] explored the relationship between forest product trade and green growth, examining whether long-term and short-term forest product trade promotes green growth, thereby fostering economic development and ensuring environmental sustainability. Solarin [23] used a stationarity test to analyze the sustainability of forest product footprints in 89 countries, finding that these countries' forest product footprints are non-stationary. Forest product footprints are driven by various factors, including natural ecological resilience, human activities, and technological development. Currently, due to factors such as the externalization of ecological and environmental costs, technological constraints, and forest certification, issues such as unsustainable timber resource extraction, inconsistency with environmental protection policies, and high pollutant emissions during the production process have emerged in the development of forest products. The sustainability of international forest product trade has attracted global attention [24-27].

Bansal [28] explores the sustainable trade development of timber and wood products in India, India uses firewood as the main consumption mode of timber, after economic reform, the contradiction between supply and demand of timber and wood products consumption in India has intensified, and while importing timber and wood products, it also exports wood products to the United States, Canada, Australia and other countries to maintain the supply and demand relationship of timber and wood products in India. de Mello et al. [29] shared four outcomes (social-ecological systems framework, political ecology, land-use change science, and social

innovation), which reinforce the sustainability of non-timber forest products from a socio-ecological perspective and provide guidance for the sustainable development of future non-timber forest product use or commercialization. Luo and Feng [30] explored the globalization of non-timber forest product tea trade in China's Wuyi Mountains. Under government fiscal policies, they strengthened producers' investment in production capital, innovated sustainable integrated production models, and ensured the development of non-timber forest products while adjusting long-term forest resource planning. This study focuses on tea product production, where sustainable integrated production models include terrace protection, application of organic fertilizers, symbiosis between tea plants and rhizobia, and ecological water systems. These measures not only ensure the sustainability of tea product production but also support the sustainability of tea product trade globalization.

Currently, comprehensive research on the sustainable development of international trade in forest products remains largely unexplored. To promote economic growth and ecological sustainability, it is necessary to investigate the sustainable development of international trade in forest products, which involves multiple factors, hierarchical structures, and blurred boundaries in production development, to fill this research gap. The fuzzy comprehensive evaluation method is a multi-factor comprehensive evaluation approach applied when a phenomenon is influenced by multiple elements. For decision-making involving numerous factors that are difficult to quantify and have unclear hierarchical boundaries, the fuzzy comprehensive evaluation method can convert qualitative indicators into quantitative indicators based on the principle of maximum membership degree, thereby providing a comprehensive evaluation of phenomena influenced by multiple factors. This method has applications in ecological environments, social development, and other areas [31-33].

This paper first analyzes the current status of China's international trade in forest products, examining the scale and product structure of such trade. It explores the connotation and evaluation dimensions of sustainable development in forest product trade, clarifying the interactive mechanisms among the three criteria layers: economic benefits, social benefits, and environmental and ecological benefits. The fuzzy comprehensive evaluation model is introduced, combined with the entropy weight method to determine indicator weights. It focuses on examining the temporal evolution characteristics of China's sustainable development capacity in forest product trade, revealing the influencing factors and driving mechanisms at different development stages through dynamic comparison. Based on regional heterogeneity, it analyzes the spatial differentiation patterns of China's sustainable development capacity in forest product trade.

2 Assessment of the sustainability of international trade in forest products based on fuzzy comprehensive evaluation

Against the backdrop of the in-depth advancement of global green development and carbon neutrality strategies, the sustainable development of international trade in forest products has become an important topic of academic and policy research. As a major player in global forest product trade, China faces multiple challenges in achieving coordinated development of economic, social, and environmental benefits while expanding the scale of its trade. This paper constructs a multi-dimensional evaluation system based on the fuzzy comprehensive evaluation method to systematically analyze the sustainable development capabilities of China's international trade in forest products.

2.1 Current Status of China's International Trade in Forest Products

Since the export trade of logs, sawn timber, engineered wood products (plywood, fiberboard, particleboard), wooden furniture, pulp, and paper products accounts for the majority of China's international trade in forest products, and these forest products have a relatively greater impact on the ecological environment during their sourcing and production processes, the constraints imposed by ecological and environmental costs on these forest products are stronger. Therefore, this paper selects logs, sawn timber, engineered wood products (plywood, fiberboard, particleboard), wooden furniture, pulp, and paper products as the primary research subjects, while other forest products are not discussed in detail in this paper.

2.1.1 Scale of international trade in forest products

Currently, China has become one of the world's leading countries in the production, consumption, and import/export trade of timber resources and forest products. China's international trade in forest products holds a pivotal position in the global forest products trade market, with major forest products such as plywood, fiberboard, wooden furniture, paper, and paper products ranking first in the world in terms of production and export volume. The table below shows the import/export trade volume and growth rate of China's forest products from 2015 to 2024. In 2024, China's international trade in forest products reached an export value of 134.464 billion USD, representing a 6.1% increase compared to 2023. The import value of forest products was 133.491 billion USD, an increase of 7.57% compared to 2023. The total value of forest product imports and exports reached 267.955 billion USD, nearly doubling from the 141.938 billion USD recorded in 2015.

Table 1: China's forest products import and export trade volume and growth rate

Year	Total trade volume/Billion dollars	Export volume/Billion dollars	Growth rate/%	Import volume/Billion dollars	Growth rate/%
2015	1419.38	701.48	9.38	717.9	7.54
2016	1522.41	782.37	11.53	740.04	3.08
2017	1628.48	829.34	6.00	799.14	7.99
2018	1838.14	918.64	10.77	919.5	15.06
2019	1919.32	902.83	-1.72	1016.49	10.55
2020	2098.17	1009.45	11.81	1088.72	7.11
2021	2211.35	1045.27	3.55	1166.08	7.11
2022	2395.18	1120.65	7.21	1274.53	9.30
2023	2508.36	1267.38	13.09	1240.98	-2.63
2024	2679.55	1344.64	6.10	1334.91	7.57

In terms of trade surpluses, China's international trade in major forest products is shown in Figure 1. Between 2015 and 2024, the scale of China's foreign trade in forest products continued to expand, and China's international trade in forest products gradually shifted from a trade deficit to a trade surplus. In 2014, China's international trade surplus in forest products reached USD 973 million.

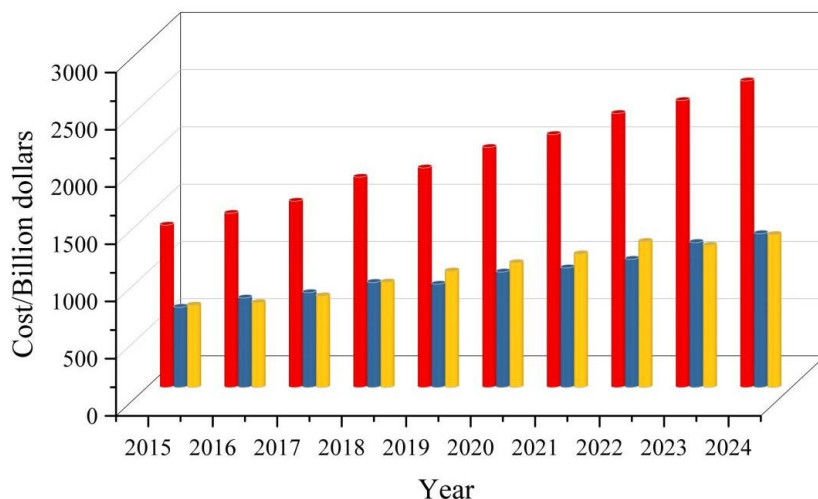


Figure 1: International trade of major forest products in China

2.1.2 Product Structure of International Trade in Forest Products

China's imports of forest products primarily consist of resource-intensive and capital- and technology-intensive wood-based forest products, such as logs, sawn timber, wood pulp, and paper and paper products. The structure of China's forest product imports from 2015 to 2024 is shown in Figure 2. It can be seen that imports of logs, sawn timber, wood pulp, and paper and paper products account for the overwhelming majority of the total import value.

Among these, due to improvements in China's paper and paper product production technology, the demand for imported high-grade paper and paperboard has decreased. Additionally, the expansion of China's forest products industry and the continuous increase in production capacity have led to an increase in the supply of paper products, resulting in a sustained decline in imports, which reached a low of 6.85% in 2024.

The import value of wood pulp as a percentage of total forest product imports has shown a steady upward trend. Due to the rapid expansion of production volume and capacity in the papermaking industry, China's market demand for raw materials such as wood pulp and waste paper has continued to rise, causing the proportion of wood pulp imports to steadily increase from 25.79% in 2015 to 29.9% in 2024.

The share of raw timber imports has shown a trend of first increasing and then decreasing. From 2015 to 2018, due to the implementation of the Natural Forest Conservation Project, there was a shortage of commercial timber production. At the same time, the rapid development of industries such as construction and decoration, furniture manufacturing, and plywood production drove up demand for wood, leading to a growing imbalance between supply and demand and thereby driving the continuous growth of raw timber imports. After 2018, the decline in international demand for wood processing products led to a decrease in exports by Chinese wood processing companies, thereby reducing the demand for imported logs. Additionally, Russia, the primary source of China's log imports, increased its log export tariffs, which also impacted China's demand for log imports to some extent. As a result, China's log imports decreased significantly after 2018.

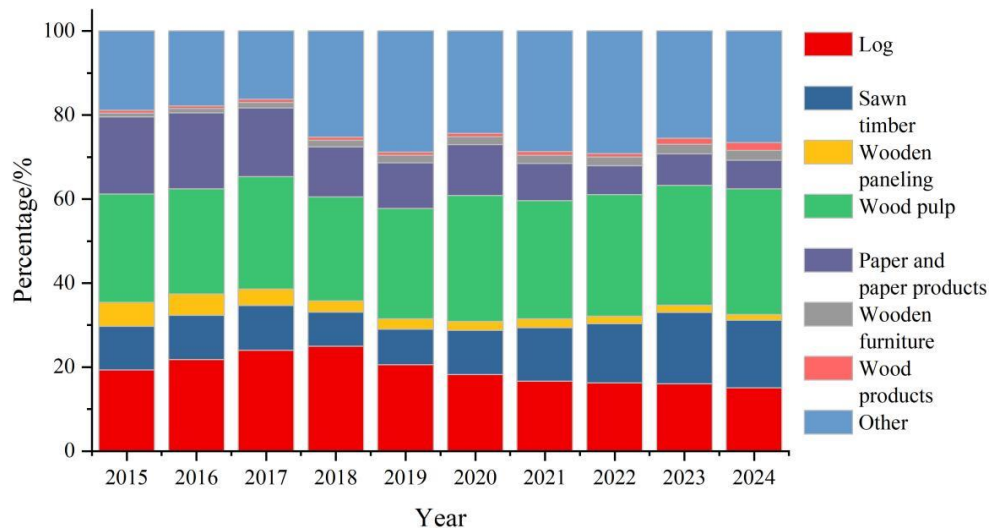


Figure 2: Structure of Imported Forest Products in China

2.2 Evaluation Model Construction

2.2.1 Evaluation Indicator System

By analyzing the current state of China's forest product foreign trade, it can be observed that the “quality” and “quantity” of China's forest product foreign trade development are not in harmony. Therefore, it is necessary to conduct an evaluation and analysis of its sustainable development capacity in foreign trade. The composition of the evaluation indicator system for China's forest product foreign trade sustainable development capacity is shown in Table 2. The evaluation indicator system for the sustainable development capacity of China's forest product foreign trade is designed as a hierarchical system consisting of the objective layer, criterion layer, and indicator layer. The indicator layer reflects the specific content of the criterion layer and is composed of individual indicators. The criterion layer consists of three major components that reflect the sustainable development objectives of China's forest product foreign trade: economic benefit indicators, ecological benefit indicators, and social benefit indicators. The objective layer is the comprehensive reflection of the criterion layer.

Table 2: Evaluation Index System for Sustainable Development Capacity

Target layer	Criterion Layer	Indicator Layer	
Sustainable development of foreign trade(U)	Economic benefit indicator(U ₁)	Total quantity indicator(U ₁₁)	The contribution rate of foreign trade to GDP growth(U ₁₁₁)
			The growth rate of trade related to intellectual property rights(U ₁₁₂)
			Growth rate of goods trade(U ₁₁₃)
		Export indicator(U ₁₂)	The contribution rate of export products to technological advancements(U ₁₂₁)
			Output industry labor productivity(U ₁₂₂)
			The proportion of primary product exports(U ₁₂₃)
		Import indicator(U ₁₃)	The proportion of industrial manufactured goods exports(U ₁₂₄)
			Imported product technology contribution rate(U ₁₃₁)
			The proportion of primary product imports(U ₁₃₂)
	Social benefit indicator(U ₂)	The proportion of imported industrial manufactured goods(U ₁₃₃)	
		Employment rate in the foreign trade industry(U ₂₁)	
		Tax rate changes in the foreign trade industry(U ₂₂)	
	Environmental ecological benefit indicator(U ₃)	Export indicator(U ₃₁)	The variation rate of per capita income in the foreign trade industry(U ₂₃)
			Utilization rate of raw materials for exported products of the unit(U ₃₁₁)
		Import indicator(U ₃₂)	Energy consumption rate of the unit's exported products(U ₃₁₂)
			Rate of change in imports of resources and resource-based products(U ₃₂₁)
			The rate of change in the import of environmental protection technologies and equipment(U ₃₂₂)

2.2.2 Model Construction

(1) Determine the fuzzy sets.

Let the judgment set be $U = \{U_1, U_2, U_3\}$;

$$U_1 = \{U_{11}, U_{12}, U_{13}\}, U_2 = \{U_{21}, U_{22}, U_{23}\}, U_3 = \{U_{31}, U_{32}\}$$

$$U_{11} = \{U_{111}, U_{112}, U_{113}\},$$

$$U_{12} = \{U_{121}, U_{122}, U_{123}, U_{124}\},$$

$$U_{13} = \{U_{131}, U_{132}, U_{133}\},$$

$$U_{31} = \{U_{311}, U_{312}\}$$

$$U_{32} = \{U_{321}, U_{322}\}$$

Let the set of evaluation comments be $V = \{V_1, V_2, V_3, V_4\}$. V_1, V_2, V_3, V_4 represent the evaluation comments for the indicators as “excellent,” “good,” “average,” and “poor,”

respectively.

(2) Determine the weights of each indicator

Let: U_{ijk} is the weight of U_{ij} with respect to a_{ijk} , and $A_j = (a_{ij1}, a_{ij2}, L, a_{ijk})$; the weight of U_{ij} relative to U_i is a_{ij} , and $A_i = (a_{i1}, a_{i2}, L, a_{ij})$; the weight of U_i relative to U is a_i , and $A = (a_1, a_2, L, a_i)$, where ijk represents the number of indicators in the criterion layer and sub-criterion layer, respectively.

(3) Determine the membership matrix

Establish grading standards for each indicator, evaluate the grades according to the standards, and obtain the membership vector R_{ijk} of U_{ijk} for the evaluation set V : $R_{ijk} = (r_{ijk1}, r_{ijk2}, r_{ijk3}, r_{ijk4})$, where $r_{ijkh} = V_{ijkh} / n$ ($h = 1, 2, 3, 4$; n is the total number of experts participating in the evaluation; V_{ijkh} is the number of experts who believe that indicator U_{ijk} belongs to level V_h), and the evaluation membership matrix is:

$$R_{ij} = \begin{bmatrix} r_{ij1} \\ r_{ij2} \\ L \\ r_{ijk} \end{bmatrix} = \begin{bmatrix} r_{ij11} & r_{ij12} & L & r_{ij14} \\ r_{ij21} & r_{ij22} & L & r_{ij24} \\ r_{ijk1} & r_{ijk2} & L & r_{ijk4} \end{bmatrix} \quad (1)$$

(4) Multi-factor, multi-level fuzzy comprehensive evaluation

1) First-level fuzzy comprehensive evaluation

Record

$$\begin{aligned} \hat{B}_{ij} &= A_j e R_{ij} = (a_{ij1}, a_{ij2}, L, a_{ijk}) e \begin{bmatrix} r_{ij11} & r_{ij12} & L & r_{ij14} \\ r_{ij21} & r_{ij22} & L & r_{ij24} \\ r_{ijk1} & r_{ijk2} & L & r_{ijk4} \end{bmatrix} \\ &= (b_{ij1}, b_{ij2}, L, b_{ij4}) \end{aligned} \quad (2)$$

where “ e ” is the fuzzy matrix synthesis operator symbol; \hat{B}_{ij} is normalized and denoted as B_{ij} , and B_{ij} is the membership vector of U_{ij} for V .

2) Second-level fuzzy comprehensive evaluation

Based on the first-level fuzzy comprehensive evaluation, the evaluation membership matrix is obtained:

$$R_i = \begin{bmatrix} B_{i1} \\ B_{i2} \\ L \\ B_{ij} \end{bmatrix} = \begin{bmatrix} b_{i11} & b_{i12} & L & b_{i14} \\ b_{i21} & b_{i22} & L & b_{i24} \\ b_{ij1} & b_{ij2} & L & b_{ij4} \end{bmatrix} \quad (3)$$

Remember

$$\hat{B}_i = A_i e R_i = (a_{i1}, a_{i2}, L, a_{ij}) e \begin{bmatrix} r_{i11} & r_{i12} & L & r_{i14} \\ r_{i21} & r_{i22} & L & r_{i24} \\ \vdots & \vdots & \ddots & \vdots \\ r_{ij1} & r_{ij2} & L & r_{ij4} \end{bmatrix} \quad (4)$$

$$= (b_{i1}, b_{i2}, L, b_{i4})$$

After normalization, \hat{B}_i is denoted as B_i , where B_i is the membership vector of U_i for V .

3) Third-level fuzzy comprehensive evaluation

Based on the second-level fuzzy comprehensive evaluation, the evaluation membership matrix is obtained:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_i \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{14} \\ b_{21} & b_{22} & \cdots & b_{24} \\ \vdots & \vdots & \ddots & \vdots \\ b_{i1} & b_{i2} & \cdots & b_{i4} \end{bmatrix} \quad (5)$$

After normalization, $\hat{B} = AeR$ is denoted as B , where B is the membership vector of U to V , i.e., the overall evaluation result.

4) Processing of evaluation results

After quantifying each element in the evaluation set V , the final evaluation result is obtained as $V = BgV^T$.

We define the quantization threshold values for various elements in the evaluation set V as follows:

$$V_1 = 100, V_2 = 80, V_3 = 65, V_4 = 50 \quad (6)$$

The final evaluation result V ranges between 100 and 50. The closer it is to 100, the stronger the sustainability capability; the closer it is to 50, the weaker the sustainability capability.

3 Empirical Analysis of Sustainable Development in China's International Trade in Forest Products

3.1 Measurement results

The initial data for this paper is sourced from China's annual statistical yearbooks, business yearbooks, and trade and foreign economic statistics yearbooks. Based on the collection of complete data for each indicator, the entropy weighting method was used to assign weights to the indicators. The weights for the indicators of China's sustainable development capacity in international trade of forest products are shown in Table 3. Among the economic benefit indicators, the contribution rate of foreign trade to GDP growth has the highest weight (0.0867), highlighting its central role in sustainability assessments. Among the social benefit indicators, the employment rate in the foreign trade industry (U_{21}) and the per capita income change rate (U_{23}) have similar weights, indicating that their contributions to social benefits are relatively

balanced. Among the environmental and ecological benefit indicators, the unit energy consumption rate per export product (U_{312}) has a weight of 0.0682, significantly higher than the change rate in imports of environmental protection technology and equipment (U_{322}) at 0.0447, revealing the critical role of energy efficiency in ecological assessments. The overall weight distribution follows the pattern of economic benefits > environmental and ecological benefits > social benefits, aligning with the development characteristics of forest product trade, which is primarily driven by economic factors while also considering ecological protection.

Table 3: Weights of Indicators Layer

Indicator	Weight	Indicator	Weight
U_{111}	0.0867	U_{133}	0.0704
U_{112}	0.0511	U_{21}	0.0483
U_{113}	0.0605	U_{22}	0.0528
U_{121}	0.0719	U_{23}	0.0486
U_{122}	0.0484	U_{311}	0.0587
U_{123}	0.0588	U_{312}	0.0682
U_{124}	0.0546	U_{321}	0.0701
U_{131}	0.0615	U_{322}	0.0447
U_{132}	0.0447		

Using the TOPSIS method, the Euclidean distances and relative proximity (C) between the positive and negative ideal solutions for China's high-quality development level of foreign trade from 2015 to 2024 were calculated. The results of the Euclidean distances and relative proximity for the positive and negative ideal solutions are shown in Table 4. The sustainable development level of China's forest product trade from 2015 to 2024 shows a continuous upward trend, with the relative proximity significantly increasing from 0.2751 in 2015 to 0.6583 in 2024, indicating a qualitative leap in sustainable development capabilities.

Table 4: Euclidean distance and relative closeness of ideal solutions

Year	D^+	D^-	C	Ranking
2015	0.1663	0.0631	0.2751	10
2016	0.1534	0.0736	0.3242	9
2017	0.1408	0.0702	0.3328	8
2018	0.1275	0.0817	0.3906	7
2019	0.1197	0.0925	0.4360	6
2020	0.1086	0.0998	0.4789	5
2021	0.0935	0.1047	0.5282	4
2022	0.0911	0.1126	0.5528	3
2023	0.0836	0.1235	0.5964	2
2024	0.0744	0.1433	0.6583	1

3.2 Dynamic Evolution Analysis

Further calculations were conducted to assess the relative proximity of economic benefits, social benefits, and environmental and ecological benefits. The results of the relative proximity analysis at the criteria level are shown in Figure 3. Specifically, the overall score growth rate from 2015 to 2022 was relatively small, primarily because the direction of change in the relative proximity of economic benefits, social benefits, and environmental and ecological benefits was not consistent. However, from 2022 to 2024, the growth rate of the comprehensive score was

relatively large, increasing from 0.5528 in 2022 to 0.6583 in 2024, with an average annual growth rate of 19.08%. This was due to the fact that economic benefits, social benefits, and environmental and ecological benefits were all growing at a relatively fast pace.

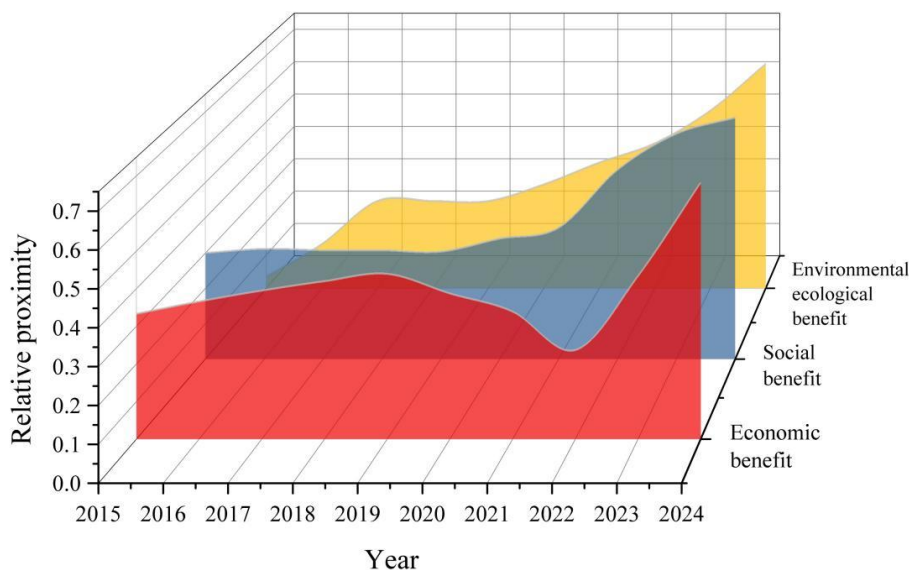


Figure 3: Results of the Relative Proximity Degree of the Criterion Layer

3.3 Spatial comparative analysis

China is divided into three regions for the purpose of evaluating the sustainability of foreign trade. The evaluation values for the three regions are shown in Table 5. The eastern region has consistently led in evaluation values, reaching 0.6115 in 2024, which is 26.71% and 43.07% higher than the central and western regions, respectively. The gap between the three regions is widening, with the difference between the eastern and western regions increasing from 0.0712 in 2015 to 0.1841 in 2024, reflecting the intensification of regional development imbalances.

Table 5: Evaluation of Sustainable Development of Foreign Trade

Year	West	Central	East
2015	0.3381	0.3913	0.4093
2016	0.3425	0.4015	0.4236
2017	0.3193	0.3872	0.4125
2018	0.3453	0.3961	0.4174
2019	0.3566	0.4147	0.4322
2020	0.3723	0.4284	0.4693
2021	0.3916	0.4436	0.4981
2022	0.4042	0.4598	0.5376
2023	0.4185	0.4673	0.5835
2024	0.4274	0.4826	0.6115

By utilizing MATLAB computational tools to calculate the comprehensive evaluation values of sustainable development in foreign trade for three regions in China, this study selected the comprehensive evaluation values of various indicator systems for sustainable development in foreign trade for the three regions in 2024. The results are presented in Table 6 and Figure 4. China exhibits a spatial differentiation characterized by “strong east and weak west.” In 2024, the eastern region ranked first with a score of 0.7084, making it the region with the strongest

sustainable development capacity for foreign trade. This indicates that a robust economic foundation contributes to a region's sustainable development capacity for foreign trade. The central region ranked second with a comprehensive evaluation value of 0.6436, significantly lower than the eastern region, indicating that its sustainable development capacity for foreign trade requires substantial improvement. The western region ranked lowest with a comprehensive evaluation score of 0.5551, indicating relatively weak economic conditions and a low level of sustainable development in foreign trade.

The eastern region outperforms the western and central regions in terms of social and economic benefits, particularly social benefits, with its robust economic foundation and advantageous geographical location providing strong support. The central region leads in ecological benefits compared to other regions. The western region lags behind in social and economic benefit indicators, with its relatively disadvantaged geographical location and level of economic development compared to cities in the central and eastern regions being key factors. Its second-place ranking in ecological benefits indicates that the western region places significant emphasis on environmental protection.

Table 6: Evaluation value of sustainable development of regional foreign trade

Region	Economic benefit	Social benefit	Environmental ecological benefit	Total value	Ranking
West	0.1472	0.1184	0.2895	0.5551	3
Central	0.1635	0.1337	0.3464	0.6436	2
East	0.2047	0.3351	0.1686	0.7084	1

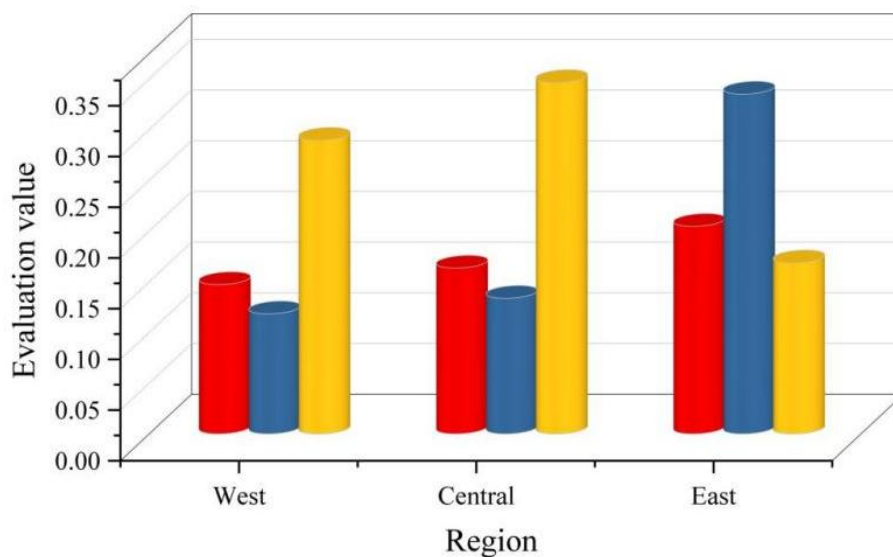


Figure 4: Evaluation value of sustainable development of regional foreign trade

4 Conclusion

This paper employs a fuzzy comprehensive evaluation model for empirical analysis and finds that China's sustainable development capacity in international forest product trade exhibits the following characteristics.

(1) Overall capacity: From 2015 to 2024, the sustainable development level of China's forest product trade has shown a continuous upward trend, with the relative proximity index increasing significantly from 0.2751 in 2015 to 0.6583 in 2024.

(2) Temporal Evolution Characteristics: From 2015 to 2022, the growth rate of the comprehensive score was relatively small, while from 2022 to 2024, the growth rate of the comprehensive score was relatively large, increasing from 0.5528 in 2022 to 0.6583 in 2024, with an average annual growth rate of 19.08%. This is due to the fact that economic benefits, social benefits, and environmental and ecological benefits are all growing at a relatively fast pace.

(3) Spatial differentiation patterns: The spatial differentiation exhibits an “east strong, west weak” pattern. In 2024, the eastern region ranked first with a score of 0.7084, the central region ranked second with a comprehensive score of 0.6436, and the western region ranked last with a comprehensive score of 0.5551.

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