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EDITED BY
Jingzhen Wang,
Beibu Gulf University, China

REVIEWED BY
Xiujuan Shan,
Chinese Academy of Fishery Sciences (CAFS), China
Qutu Jiang,
The University of Hong Kong,
Hong Kong SAR, China

*CORRESPONDENCE
Xuefeng Wang
xuefeng1999@126.com

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Assessing potential driving factors of the ecosystem service value of mariculture shellfish in China using a structural equation modeling approach

Yixin Gu[1], Lifei Wang[2], Shaoliang Lyu[1], Jianyu Dong[1], Bilin Liu[3] and Xuefeng Wang[1]*

[1]Fisheries College, Guangdong Ocean University, Zhanjiang, Guangdong, China, [2]Department of Biological Sciences, University of Toronto Scarborough, Toronto, ON, Canada, [3]College of Marine Science, Shanghai Ocean University, Shanghai, China

China is one of the major mariculture countries for shellfish in the world and provides more than 70% of the total global shellfish production. However, there is limited knowledge of the potential driving factors of the ecosystem service value of mariculture shellfish in China. Understanding what factors and how they drive the ecosystem can provide reference for further improving the ecosystem service value of mariculture shellfish, which is both theoretically and practically important for promoting the development of marine fishery economy in China. In this study, data of six major mariculture shellfish species in nine coastal provinces of China from 2009 to 2020 were analyzed using a structural equation modeling approach to quantify the effects of resource distribution characteristics and market demand on the ecosystem service value of mariculture shellfish in China. The results indicated that both resource distribution characteristics and market demand are important driving factors of the ecosystem service value of mariculture shellfish in China. Specifically, from the perspective of path coefficient, market demand plays a more important role (0.58) than resource distribution characteristics (0.36) in influencing the ecosystem service value of mariculture shellfish in China. Therefore, the research results for shellfish marine culture can be summarized as: (1) to actively respond to changes in shellfish market demand, (2) to enhance development planning for coastal shellfish cultivation area, and (3) to strengthen systematic management of mariculture shellfish resources. Results of this study could provide theoretical support and serve as a basis for promoting sustainable development of shellfish culturing industry and fisheries economy in China.

KEYWORDS

China, ecosystem service value, mariculture shellfish, marine fisheries resources, structural equation modeling

1 Introduction

China is one of the major mariculture countries in the world, with more than 70% of the total global mariculture production (Dai et al., 2022). With the exploitation of marine biological resource, mariculture has become the core industry in the "Blue Granary" project (Zhao, 2021). Nowadays the promising development of mariculture is not only essential for improving residents' dietary structure, but also important for maintaining food security to humans (Liu et al., 2022). The Food and Agriculture Organization of the United Nations (FAO) predicted that mariculture products would become the main source of food worldwide in the next fifty years (The State of World Fisheries and Aquaculture 2022, 2022). Shellfish mariculture is playing an increasingly important role in relieving the pressure of food demand, compensating for global food shortages, and increasing the income of fishermen (Gomes et al., 2017). Meanwhile, the development of mariculture shellfish products has not only brought significant economic benefits to China, but also promoted the trade cooperation among China, *ASEAN*, and the coastal countries of "the Belt and Road" (Noman et al., 2018; Zhang and Li, 2022). The production and trade of mariculture shellfish products have been rapidly increasing in China (Zhang et al., 2021). As of 2020, China's mariculture shellfish production has reached 14.8 million tons, accounting for 83.67% of the total global production (The State of World Fisheries and Aquaculture 2022, 2022).

During the expansion process and intensification of shellfish mariculture practices in China, there is also an increase of stress level on the limited carrying capacity of coastal marine ecosystems to afford the increasing mariculture space or density and market demand (Liu et al., 2022; Yan et al., 2022). Identifying the constraints and key factors can provide clues for improving ecosystem service value of mariculture shellfish in China (Cao and Yang, 2022). In 2021, Chinese government proposed to develop marine economy as one of the goals for the "14th Five-Year Plan" and "2035 Long-Term Goal" (Liu and Li, 2023). The exploitation of marine resources has become a hotspot for economic development with the orientation from high-speed development to high- quality development (Wang et al., 2021). Therefore, enhancing the core competitiveness of the shellfish industry is of great importance for promoting high- quality development of the marine economy in China (Yang and Chen, 2022).

Core competitiveness is an important evaluation indicator for measuring the level of industrial development (Nguyen et al., 2022). Many studies have analyzed the competitiveness of Chinese fisheries by using relevant indicators such as resource distribution characteristics coefficient, international market share, and trade complementarity index (Feng, 2019). Based on Porter's diamond model, Zhao et al. suggested that the competitiveness of marine fisheries is mainly influenced by basic production, market demand, related enterprises, and social environment (Yang and Chen, 2022). Shan et al. examined the competitiveness of marine fisheries across countries, and measured the resource distribution characteristics coefficient and the dominant comparative advantage index of Chinese fisheries catch, and concluded that Chinese fisheries were facing challenges in the utilization of resource distribution characteristics and the implementation of marine environmental protection (Shan and Jiang, 2005). However, these studies mainly focused on the point-to-point direct relationships, but overlooked the relationships of dependent variables and lacked a comprehensive perspective (Zhang et al., 2019). Therefore, it is imperative to choose suitable statistical approaches to determine the potential driving factors of the ecosystem service value of mariculture shellfish in China. As a novel and promising modeling approach, structural equation model (SEM) integrates path analysis with multiple factor analysis (Yang et al., 2018; Lai et al., 2022a; Ou et al., 2022). Compared with traditional statistical methods, SEM can not only reveal the interrelationship and strength of individual influencing factors, but also fit and evaluate the overall model, thus providing a more comprehensive understanding of the underlying mechanisms that affect response variables (Cao et al., 2020). SEM has been applied in psychology, economic management, social behavior, and other fields (Du et al., 2015), but there is little research reported on fisheries management (Zhang et al., 2022).

The objective of this research is to quantify how the potential driving factors influence the ecosystem service value of mariculture shellfish in China. The SEM approach was used to analyze the influencing factors and construct a path map. Results of this study could provide theoretical support for improving the ecosystem service value of China's mariculture shellfish industry, and also serve as a basis for promoting the sustainable development of marine fisheries in China.

2 Materials and methods

2.1 Data sources

According to the current distribution of mariculture shellfish industry in China, six major mariculture shellfish species (oyster, ark clam, mussel, scallop, clam, and razor clam) in nine coastal provinces (Liaoning, Hebei, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi, and Hainan) from 2009 to 2020 were analyzed. All the historical data were derived from China Fishery Statistical Yearbook (Fishery Bureau of Ministry of Agriculture and Rural Affairs of China (2010–2021)). The original data were transformed with log10 function before analysis, and the records with missing or invalid values were excluded. There 105 sets of valid data were finally pooled to the SEM analysis (S1).

2.2 Variable selection

The elements of marine production can be optimized in different proportions in spatial form in the market economy, and the optimizing process will update the layout of the whole marine industry (Wei et al., 2021). The mariculture shellfish industry in

China is mainly dependent on natural conditions (Zheng et al., 2020; Liu et al., 2022).The area suitable for cultivating shellfish and hatching with more fisheries practitioners are mainly distributed in coastal area (Liu and Li, 2023). The advantages of regional resource distribution characteristics underpin the spatial pattern of the mariculture shellfish industry in China (Zhang et al., 2004). The competitive advantage mostly depends on the market demand (Cao and Yang, 2022), the greater competitiveness indicating that more domestic and foreign market share, (Gao et al., 2018).

The ecosystem service value of mariculture shellfish (fishery output value herein) depends on factors as follow: resource distribution characteristics (shellfish mariculture production, shellfish mariculture area, shellfish seeding, fishery practitioners) and market demand (aquatic products import volume and export volume) (Chen et al., 2012; Miao et al., 2014).Therefore, this study is to build a model to assess the roles of factors affecting the ecosystem service value of mariculture shellfish (Jacobucci et al., 2016). Three latent variables were included: the ecosystem service value of mariculture shellfish, the resource distribution characteristics, and the market demand (Table 1). Two hypotheses have been proposed to explain which factor has a positive impact on the ecosystem service value of mariculture shellfish:

H1: Resource distribution characteristics.

H2: Market demand.

2.3 Model building

2.3.1 Data processing

Due to the different units of the variables in this study, the data were log10-transformed before conducting statistical analysis. Values of the indices were standardized to the same order of magnitude, and 105 sets of standardized data were obtained.

2.3.2 Model structure and configuration

In this study, structural equation modeling was used to determine the weight of factors influencing the ecosystem service value of mariculture shellfish in China (Yang et al., 2018). The principal goal of SEM is to develop models to evaluate and represent the underlying causal processes (Li et al., 2018; Ma et al., 2022). So, the measurement model and structural model can be constructed based on the relationships between variables (Fox, 2006; Zhao and Zhu, 2014; Wang et al., 2022).

$$\eta = B\eta + \Gamma\xi + \zeta \tag{1}$$

$$X = \wedge x\xi + \delta \tag{2}$$

$$Y = \wedge y\eta + \epsilon \tag{3}$$

Equation (1) is the structural model, in which η is the endogenous latent variable; ξ is the exogenous latent variable; B and Γ are coefficient matrices; and ζ is an error term. Equations (2)and (3) are both measurement models, in which Y represents the measurable variables for the endogenous latent variable; Λy is the correlation coefficient matrix between the endogenous latent variables and their measurable variables; ϵ represents measurement errors; X represents the measurable variables for the exogenous latent variables; Λx is the correlation coefficient matrix between the exogenous latent variable and its measurable variables; and δ represents measurement errors.

According to the above hypothesis, resource distribution characteristics, market demand and ecosystem service value of mariculture shellfish in China were regarded as the latent variables, which were described using 7 measured variables. In summary, the first endogenous latent variable (the ecosystem service value of mariculture shellfish in China) was described by one measured variable (fishery output value). The second exogenous latent variable (resource distribution characteristics) was described by four measured variables (shellfish production, Shellfish seeding, fishery practitioners, shellfish mariculture area). The third exogenous latent variable was market demand, expressing as the aquatic products export value and the aquatic products import value. The model was established by using the R "Lavaan" package, of which the maximum-likelihood estimation method was used (Fan et al., 2016; Kline, 2016; Li et al., 2022; Shi et al., 2022).

2.3.3 Model fitting and assessment

The model fit index is a statistical indicator that examines how well a theoretical structural model fits the data. The model fit indices of distinct categories can be measured for model complexity, sample size, relativity, and absoluteness. Therefore, the following seven commonly used indicators were selected (Yuan et al., 2017).

Chi square test (X^2), the model has a good fitting effect when P value > 0.05.

TABLE 1 The indicator variables in structural equation model.

Indicator Classification	Latent Variable	Observations Variable
Result Metrics	Ecosystem service value of mariculture shellfish	Fishery output value
Influencing Factor Measurements	Resource distribution characteristics	Shellfish mariculture production
		Shellfish mariculture area
		Shellfish seeding
		Fisheries practitioners
	Market demand	Aquatic products export volume
		Aquatic products import volume

Goodness of Fit Index (*GFI*). The more *GFI* approaches to 1, the better the model fits the data. *GFI* > 0.900 is usually used as the threshold.

Relative Fit Index (*RFI*). *RFI* > 0.90 is considered acceptable.

Comparative Fit Criterion (*CFI*) is between 0 and 1. *CFI* equals 1 if the model fits the data perfectly.

Standardized Root Mean Square Residual (*SRMR*) is like *RMSEA* and should be< 0.09 for a good model fit.

Tucher Lewis Index (*TLI*) is a non-normed fit index, *TLI* > 0.90 is considered acceptable.

Root Means Square Error of Approximation (*RMSEA*) can overcome the drawback of the overall different value influenced by the estimated parameters in model validation. *RMSEA* is less than 0.05 when the fitness of the model is good. *RMSEA* is higher than 0.1 when the fitness of the model is bad, and modification is needed. *RMSEA* between 0.050 and 0.100 means that the model is not much satisfied but acceptable.

3 Results

3.1 Spatiotemporal characteristics of mariculture shellfish

The distribution of mariculture shellfish along the coast of China showed an overall agglomeration trend (Figure 1) characterized with high at both ends and low in the middle. Provinces including Shandong, Fujian, Liaoning, and Guangdong were the main high-yield coastal provinces, accounting for 80% of the coastal provinces, with 44.08 million tons, 31.41 million tons, 26.31 million tons, and 22.51 million tons, respectively. The production of mariculture shellfish in Shandong Province accounts for over 25% of the total national.

The overall area of shellfish mariculture decreased significantly in 2016, with a slight downward trend thereafter. Since 2009, Liaoning Province and Shandong Province had consistently

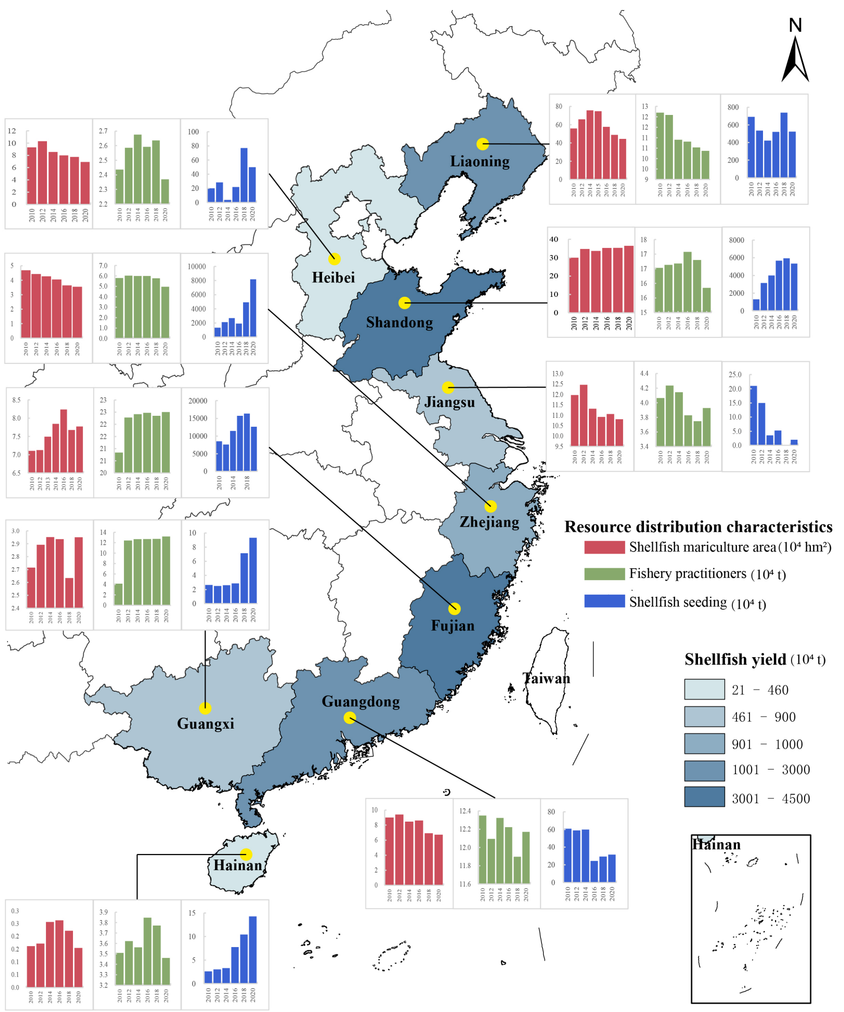

FIGURE 1
The indicators shellfish production, mariculture area, shellfish seeding, fishery practitioners of resource distribution characteristics of mariculture shellfish in China. The map color saturation represents the shellfish mariculture production, and the histogram color distinguishes different indicators.

ranked in the top two, while the mariculture area in Hainan province was relatively small. The top three provinces in terms of shellfish seeding were Fujian, Zhejiang, and Shandong Province, with input exceeding 25 million tons from 2009 to 2020. Since 2016, the number of shellfish seedings in Hainan Province had been increasing annually (with an increase rate of 17%), while the number of shellfish seedings in Guangdong Province had been decreasing, far below the average level. Although Fujian Province ranked first in the number of shellfish seedings, the mariculture area was comparatively small. As the primary industry, fisheries in Fujian, Shandong, and Liaoning provinces had attracted more fishery practitioners. In 2020, the number of fishery practitioners reached 490 000, accounting for 40% in coastal areas.

The overall shellfish mariculture had been in rapid developing nationally, which was shown in indices such as fishery output value, and the import and export volume of fishery products, with a decline in fishery output value only in 2011 (Figure 2). Both the volume of import and export of fishery products had declined since 2019, partly due to the Covid-19 pandemic.

The differences in fishery output value between provinces was shown in Figure 3. The highest fishery output value with a continuous upward trend in Shandong, Fujian, Guangdong, and Liaoning provinces contributed substantially to the northern and southern marine economic zones. The import and export volume of aquatic products had shown an growth trend in all though varied in some year. The top four provinces of export volume were Fujian, Shandong, Guangdong, and Liaoning, while the top four provinces of import volume are Shandong, Liaoning, Guangdong, and Fujian. In recent years, the development of fisheries in Fujian Province had been more and more prominent, and the gap between imports and exports after 2016 expanded, with a difference of 3.88 million dollars in imports and exports in 2020. The neighboring province Jiangsu was slower than Fujian, and the export volume in 2020 is less than 20% of Fujian Province.

3.2 Model validation

3.2.1 Multivariate cross correlation

Mariculture shellfish production showed high correlation (r=0.86) with the mariculture area (Figure 4). The correlations between the import and export volume of aquatic products and the production of mariculture shellfish, as well as the fishery practitioners, had reached over 0.65. Both the significant increase in the production of mariculture shellfish and the fishery practitioners had greatly promoted the development of the import and export scale of aquatic products.

3.2.2 Goodness-of-fit test

The SEM for the ecosystem service value of mariculture shellfish in nine coastal provinces of China were successfully built. The multiple parameter evaluations were conducted for the SEM, and all met the standards (Table 2): *P* = 0.104, *GFI* = 0.972, *RFI* = 0.958, *CFI* = 0.995, *TLI* = 0.981, *RMSEA* = 0.085, *SRMR* = 0.023. The minimum acceptance criteria for RMSEA< 0.90 and SRMR< 0.08, respectively, and all of this measurement model fitness met the critical value requirements. Therefore, the model fitting evaluation met the standards, indicating that the indicator system and logical relationship of the three latent variables were reasonable and reliable.

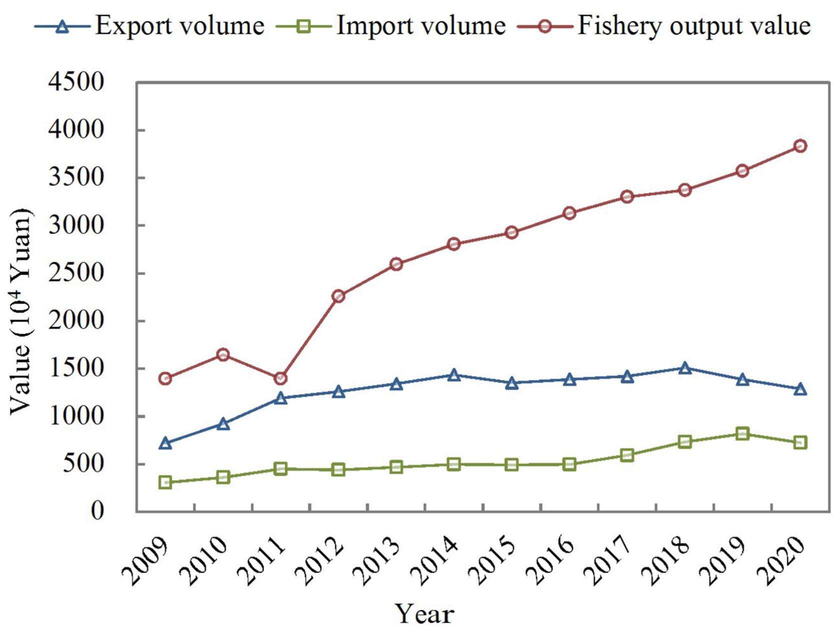

FIGURE 2
The trend of fishery output value, and the import and export volume of fishery products in China's coastal provinces from 2009 to 2020.

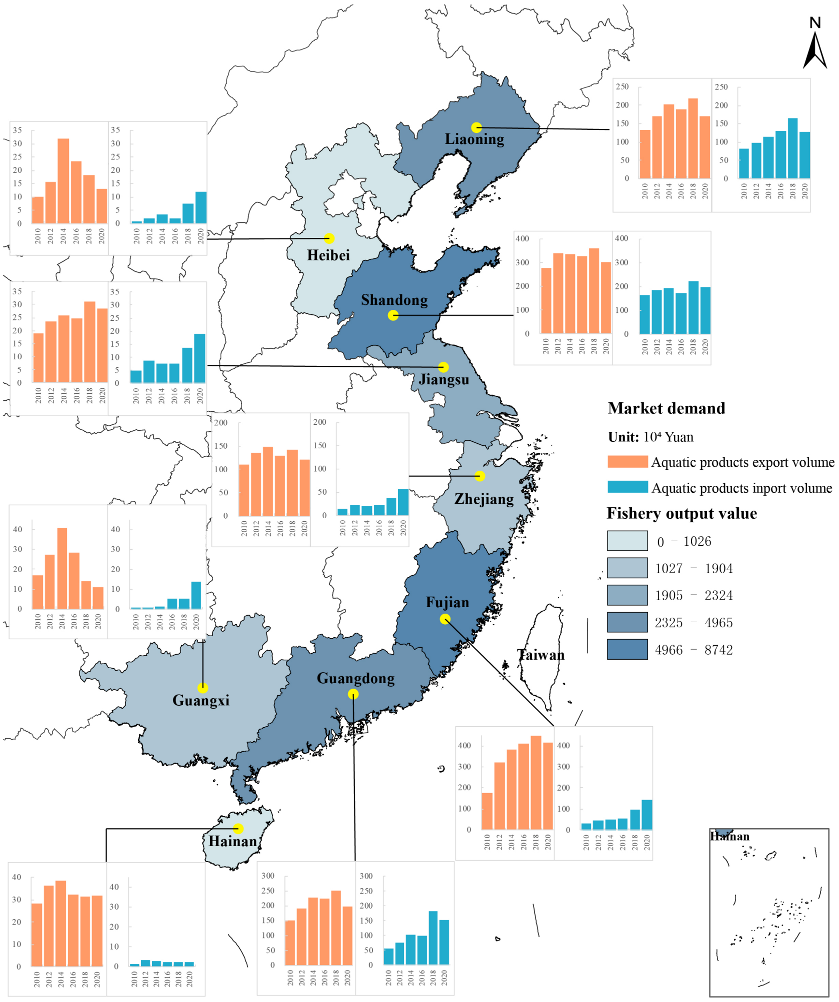

FIGURE 3
The indicators fishery output value, import volume, and export volume of market demand of mariculture shellfish in China. The map color saturation represents the fishery output value, and the histogram color distinguishes different indicators.

3.3 Path graph on SEM

As for the direct effects, the correlation coefficients between the ecosystem service value of Chinese mariculture shellfish and resource distribution characteristics, as well as market demand, were 0.36 and 0.58 respectively. It indicated that the impact of resource distribution characteristics and market demand on the ecosystem service value was significant. Among them, the competitive advantage of Chinese mariculture shellfish in terms of market demand was the most prominent (Figure 5).

The correlation coefficients between the latent variable resource endowment and the observed variables of shellfish yield, mariculture area, shellfish seeding, and fishery practitioners with were 0.87, 0.69, 0.73, and 0.86, respectively. The correlation coefficients between the latent variable market demand and the observed variables aquatic product export volume, import volume, were 0.90 and 0.99, respectively. The correlation coefficient between the observed variable total fishery output value and the ecosystem service value of Chinese mariculture shellfish was 1.00. Meanwhile, the correlation coefficients of mariculture area had a negative impact on the number of fishery practitioners and the export volume of aquatic products with correlation coefficients of -0.41 and -0.22, respectively. In summary, the seven observed variables had a positive and significant impact on the three latent variables.

4 Discussions

4.1 Resource distribution characteristics of mariculture shellfish in China

China holds the Yellow Sea, the Bohai Sea, the East China Sea and the South China Sea, which are rich in marine resources and large scale of mariculture (Lai et al., 2022b), which is the basis for the ecosystem service value of Chinese shellfish products (Niu, 2015). In terms of the scale of Chinese mariculture industry, shellfish is the most important sector in both mariculture area and the correlation coefficients between the observed variables of production. This study found that the total area of mariculture in China in 2020 was 1995.55 thousand hectares, of which 1197.41 thousand hectares were used for shellfish culturing,

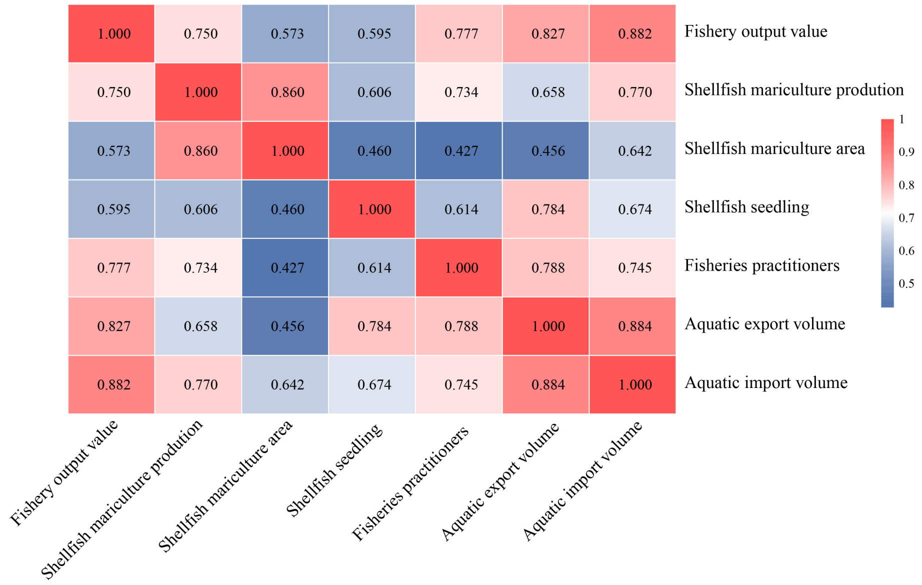

FIGURE 4
Pearson correlation heatmap among all indicators.

TABLE 2 The goodness-of-fit test results of structural equation model.

	P	GFI	RFI	CFI	RMSEA	SRMR	TLI
Model	0.104	0.972	0.958	0.995	0.085	0.023	0.981

accounting for approximately 60.01%. Owing to the increasing production capacity, the production of mariculture shellfish reached 14.8 million tons in 2020, accounting for 83.67% of the global total (Teng et al., 2021).

The shellfish seedlings/hatchery is vital for the development mariculture industry (Bai et al., 2022). Compared with the step-by-step growing trend of mariculture shellfish production, the quantity of shellfish seedings varied rather largely. At present, the specific

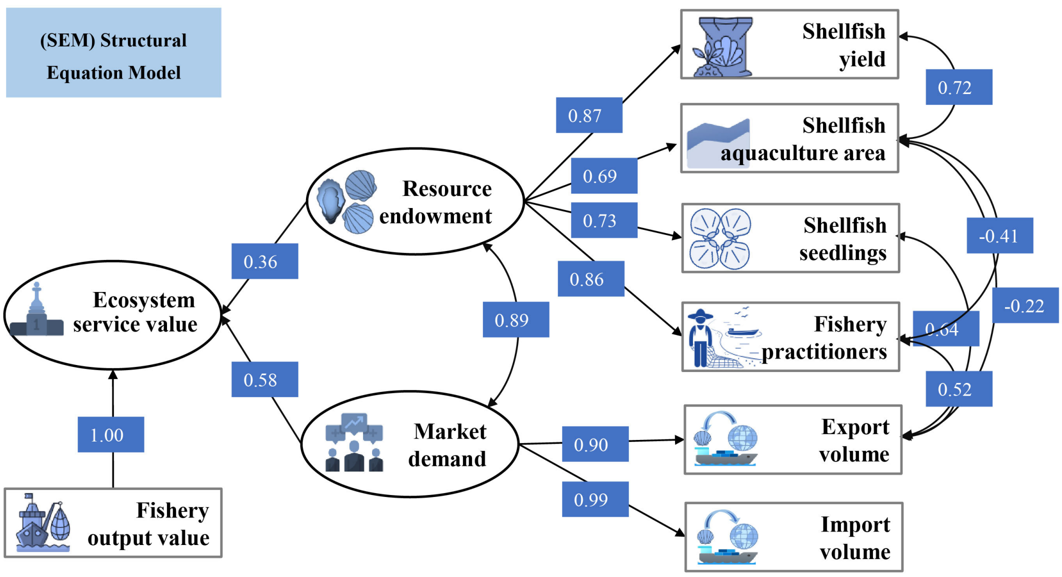

FIGURE 5
Path diagram based on structural equation model. The ellipses represent latent variables. The variables in the rectangle are observation variables. The value on the arrow line is the Pearson correlation coefficient.

shellfish breeding institutions and seed farms for advanced biological technical application are still insufficient in China, with only some such farms established in Zhejiang, Jiangxi, and Hunan provinces (Guan et al., 2022). The introduction of improved varieties can quickly form new industrial clusters and play a huge role in promoting industrial development (Tang et al., 2022). In addition, farmers will transfer the shells from the south to north, or from north to the south in coastal waters to provide more preferred habitats for shells rapid growth, intending to making more profit (Lai et al., 2022b). The transfer of shells during process of culturing possibly cause potential threats such as confusion in genetic background and a deficiency of high-quality large-sized seedlings (Lai et al., 2022b). In such situations, the quality of shell seeding are more dependent on local breeding selection or the introduction of foreign seed-parent (Liu et al., 2020). From the perspective of germplasm resources protection, both updating the cultivation technology and optimizing the infrastructure of shellfish seedling are fundamental to high-quality development of fishery (Wang and Han, 2017). For example, the NSSP of the United States has detailed research results in shellfish seedling planning and breeding, and has established a set of shellfish seedling quality control system (van Senten et al., 2020).

The mode of mariculture in coastal area of China is also in ungrading (Feng et al., 2004). The overcrowded shellfish mariculture in coastal waters have posed threats on wetlands and product quality/food safety (Jiang and Mu, 2022; Tian P. et al., 2022). In 2015, China endeavored to rectify the mariculture environment and cleared a large number of illegal mariculture area (Jiang et al., 2021). After 2017, the implementation of the "13th Five-Year Plan" and the rapid advancement of marine development activities (Liang et al., 2018). Due to the saturated/over saturated of the shellfish culturing capacity, and the area of shellfish mariculture is facing the trend of shrinkage (Gu et al., 2022). Therefore, countermeasures are imperative to improve the capacity of mariculture shellfish (Figure 6) (Liang et al., 2018). Marine ranching is potential and an effective means to alleviate the deterioration of the coastal environmental pollution and the decline of fishery resources (Suo et al., 2023). It's also important to fulfill the marine ecological civilization (Zhou et al., 2019). Additionally, the utilization of mudflat for shellfish culture is also promising (Meng and Feagin, 2019). Mendoza et al. assessed the coastal protection capacity of the mudflats and proposed the Coastal Resilience Index from Remote Sensors (CRIfRS) method to improve the coastal protection capacity of mudflats (Bian et al., 2020; Mendoza et al., 2022). The protection of coastal mudflats and wetlands is helpful to solve the "saturation" of coastal area, but also to develop a rising ecological industry (Cui L. et al., 2022).

In addition, the number of fisheries practitioners has been increasing accordingly with the expansion of mariculture. The experienced culturing personnel are irreplaceable in the development of the whole industry (Xu and Gao, 2022). Although the coastal governments provide financial support for mariculture research, the overall amount of investment is still insufficient (Miao et al., 2023). In recent years, the aquatic seed industry is causing wide concerns of fisheries management agencies, researchers and farmers (Zhang, 2016; Hu et al., 2020). The sustainable development of shellfish industry in China depends on the integration of scientific research, culturing technique and management strategies (Li, 2019; Chen, 2022). The EU Common Fisheries Policy established the scientific committee system for marine fisheries, offering scientific supports on fisheries development (Jensen et al., 2014).

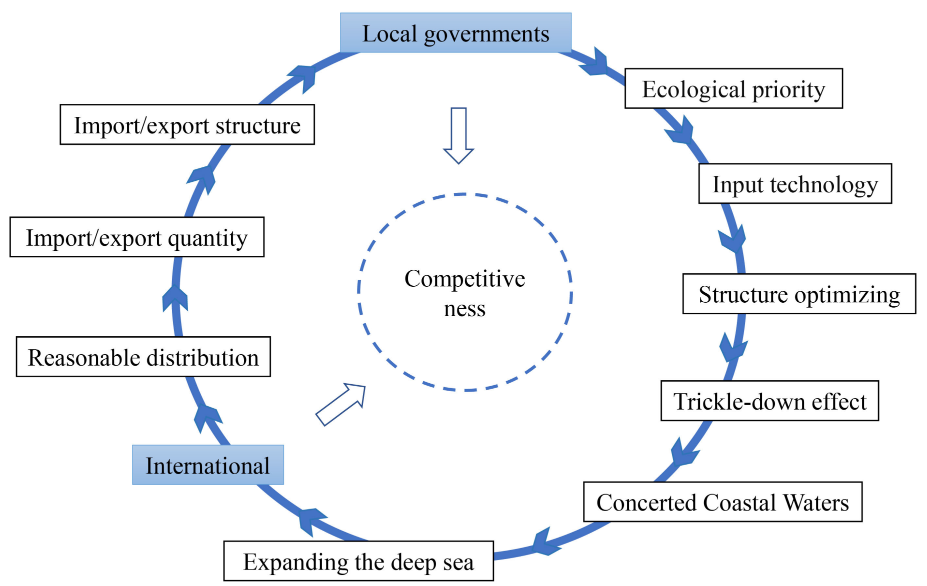

FIGURE 6
Framework proposed based on the research on the ecosystem service value of mariculture shellfish in China.

4.2 Market demand of mariculture shellfish in China

The growing demand for aquatic products in China significantly influenced the development of the global seafood market (Li et al., 2011; Peng et al., 2021). China's fishery economy reached as high as 400,482 billion dollars in 2020. This study showed that China's import and export of aquatic products amount to 34,606 billion dollars in 2020 (The State of World Fisheries and Aquaculture 2022, 2022).

The mariculture shellfish has strong international competitiveness in China (Zhang et al., 2004). In 2011, there were 158,500 tons of shellfish exported in China, accounting for 25.07% of the world's total shellfish exports, which made China the world's largest shellfish export country. The quality and added-value of shellfish products in China still needs to be improved (Feng, 2019). Tan et al. quantitatively analyzed the competitive advantages and market share of Chinese shellfish trade (Tan et al., 2020). Despite the huge scale of mariculture shellfish industry in China, the mariculture structure of shellfish "high at both ends and low in the middle" still has gaps in meeting the demands for consumers (Tan et al., 2020). The shellfish industry tends to be low-level and redundant, with making profit as the single target (Niu, 2015; Miao et al., 2021).

The results of the study showed that aquatic products trade contributed to the rapid development of marine economy in coastal area, though the culturing industry was scattered and unbalanced in terms of regional distribution (Xu and Yang, 2022). The characteristics of regional distribution implies that the development of shellfish industry in China should be market oriented, i.e. the quality/seafood security of shellfish quality is top important and the quantity is subsequent. So the utilization of culturing coastal waters and culturing technique, culturing species are fundamental to the supply of shellfish (Wang and Somogyi, 2019). Additionally, increasing the shares in the international market of shellfish products is also an essential part of competitive advantage (Figure 6) (Li, 2019; Wang and Somogyi, 2019).

Fisheries management strategies should be made according to the characteristics of shellfish industry. The first priority for regions with abundant shellfish should increase their shares in international market (Li et al., 2011), and for other regions should increase the sustainable utilization of culturing area (Ferreira et al., 2007; Meng and Feagin, 2019; Su et al., 2020; Lyu et al., 2022). Meanwhile, to alleviate the global risks such as COVID-19 on shellfish marine culture industry, the whole supply chains needs to be strengthened from shell seeds breeding to culturing technique and the products market (Zhang and Ma, 2022).

5 Conclusion

This study investigated the potential driving factors of the ecosystem service value of mariculture shellfish in China using data of six mariculture shellfish species in nine coastal provinces of China from 2009 to 2020. The SEM approach was used to quantify the impacts of resource distribution characteristics and market demand on the ecosystem service value of mariculture shellfish in China. The results indicated that both resource distribution characteristics and market demand are important driving factors of the ecosystem service value of mariculture shellfish in China. Specifically, from the perspective of path coefficient, market demand plays a more important role than resource distribution characteristics in influencing the ecosystem service value of mariculture shellfish in China. Future directions would be to incorporate the import and export volume of fisheries products as a response variable to market demand, although such import and export volume data are still limited. Results of this study could provide theoretical guidance for improving the competitiveness of China's mariculture shellfish industry, and serve as a basis for promoting the development of marine fisheries economy and supporting the sustainability of marine resources and coastal ecosystems in China.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the animal study because this study did not involve animal tissue sampling, and studied aquaculture shellfish from a data and model perspective.

Author contributions

YG: methodology and initial draft preparation. LW: investigation and methodology. SL, BL and JD: revision and data collection. XW: experiment design, reviewing and editing, supervision, and funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.1232211/full#supplementary-material

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