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Research on Revitalization Strategies for Fujian Traditional Boats' Intangible Cultural Heritage Driven by Cultural Genes: A Dynamic Synergistic Path Based on the FAHP-DEMATEL Hybrid Model

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Abstract: This study focuses on the inheritance and revitalization of Fujian's intangible cultural heritage craftsmanship. By integrating longitudinal historical analysis with cross-case comparisons, it proposes a four-pronged approach: "educational inheritance—digital innovation—industrial integration—community co-creation." Employing a hybrid FAHP-DEMATEL methodology, we constructed a "Cultural Genes-Strategic Synergy" model to quantify strategy weights and uncover causal relationships. Results indicate that industrial integration (weight: 0.312) serves as the core driver, significantly influencing community co-creation and educational transmission. The model's validity was validated through the Lin Peizong team's practical case study, which also proposed a "Dynamic Evaluation-Feedback Mechanism" to provide theoretical support and a practical paradigm for revitalizing intangible cultural heritage.

Keyword: Fujian Ship Intangible Cultural Heritage; Living Heritage; Fuzzy Hierarchical Analysis Process; DEMATEL; Industrial Integration; Cultural Genes

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1. Introduction

The preservation of Fujianese shipbuilding heritage involves both craft transmission and maritime cultural continuity. While UNESCO stresses balancing traditional preservation with modern innovation, Fujian ships face technological disruption, inheritance gaps, and limited innovation. Existing studies address preservation and industrial integration but lack systematic strategy prioritization. This study builds a "Cultural Gene–Strategy Synergy" model using FAHP-DEMATEL, where FAHP quantifies strategy weights and DEMATEL maps causal networks to optimize structures and identify core driving pathways[1-5].

2. Cultural Gene-Based Strategy Classification and FAHP Weighting

FAHP quantifies subjective strategy weights via fuzzy math, addressing uncertainties in expert judgments[6–7]. DEMATEL

reveals causal relationships, identifying core drivers and key paths. Combined, FAHP sets priority weights, while DEMATEL adjusts them via centrality to reflect actual influence.

2.1. Cultural Gene-Based Strategy Classification and FAHP Weighting

The core strategy layer comprises educational inheritance (B1), digital innovation (B2), industrial integration (B3), community co-construction (B4), and cultural dissemination (B5). Material genes like watertight compartment technology rely on B2, while intangible genes such as Maritime Silk Road identity depend on B4, forming a "decoding–recoding" pathway for cultural renewal. Ten experts—heritage scholars, craftsmen, tourism managers, and a cultural officer—participated in FAHP-DEMATEL analysis, using linguistic terms (e.g., "equal" "slight," "strongly more important") for pairwise comparisons, converted into triangular fuzzy numbers. Fuzzy consistency checks ensured FCR < 0.1; results are shown in **Figure 1**.

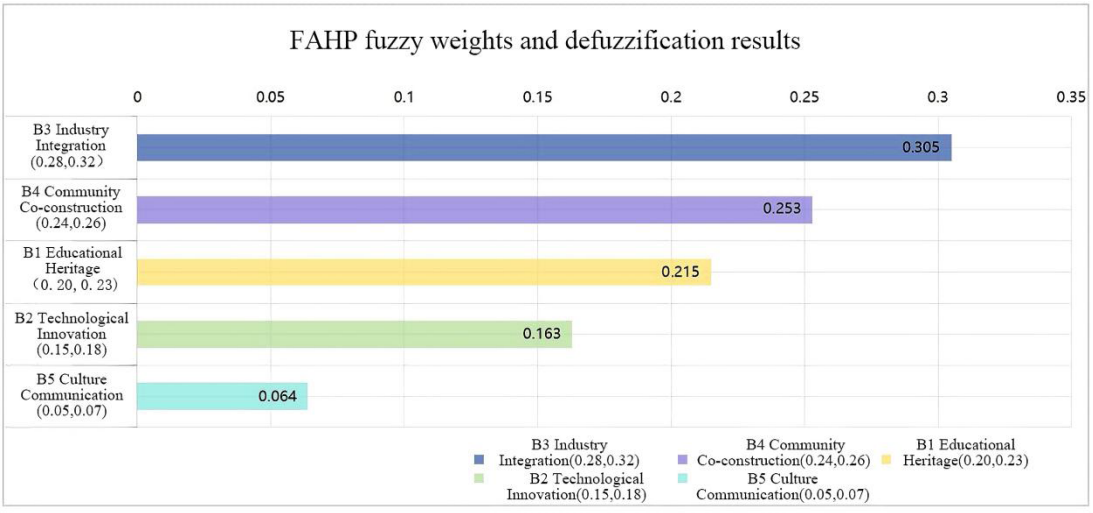

Figure 1. FAHP Fuzzy Weight Defuzzification Results (α=0.5)

2.2. DEMATEL Analysis of Causal Relationships Among Strategies

Constructing the Direct Impact Matrix: Experts rated the degree of mutual influence among the five strategies (0–4 points, where 0 = no impact and 4 = strong impact), as shown in **Table 1**.

Table 1. Direct Impact Matrix (0-4 point scale, average expert score)

Strategy	B1	B2	B3	B4	B5
B1	0	2	1	3	0
B2	1	0	2	1	4
B3	4	3	0	4	2
B4	2	1	3	0	1
B5	0	0	1	0	0

(Note: Scoring range is 0-4 (0=no impact, 4=strong impact). Experts include intangible cultural heritage scholars (4), inheritors (2), enterprise managers (3), and government representatives (1).)

Calculating Centrality and Causality: Using the normalized matrix and total influence matrix, quantify the "centrality" (importance) and "causality" (driving force) of each strategy.

DEMATEL Direct Influence Matrix Formula:

$$N=\frac{X}{\sum_{j=1}^{n} x_{ij}} \quad (1)$$

Calculation of the Total Influence Matrix T:

$$T=\lim_{k\to\infty}\left(N+N^2+N^3+\cdots+N^k\right)=N(I-N)^{-1} \quad (2)$$

Centrality and Causality Definitions: "Centrality = R + C, Causality = R - C"

Where R represents row sum and C represents column sum. The results are shown in **Table 2**:

Table 2. Overall Impact Matrix Results

Strategy	B1	B2	B3	B4	B5
B1	0.12	0.25	0.18	0.30	0.05
B2	0.10	0.15	0.22	0.18	0.35
B3	0.42	0.38	0.00	0.45	0.20
B4	0.25	0.10	0.30	0.15	0.08
B5	0.02	0.03	0.08	0.05	0.00

Industrial Integration (B3): With the highest centrality (8.2) and positive causality score (+1.5), it serves as the core driving strategy;

Educational Continuity (B1): Its negative causality score (-0.8) indicates significant influence from other strategies.

3. Comprehensive Weight Calculation for Mixed Models

3.1. Comprehensive Weight Calculation

Comprehensive Weight = FAHP Weight × DEMATEL Centrality: Combining the fuzzy weight from FAHP with the centrality from DEMATEL to calculate the comprehensive priority of the strategy [8-10].

Table 3. Composite Weight = FAHP Weight × DEMATEL Centrality

Strategy Layer (B)	FAHP Weight	DEMATEL Center of Mass	Composite Weighting
B1 Educational Heritage	0.215	6.8	0.183
B2 Technological Innovation	0.163	7.0	0.150
B3 Industrial Integration	0.305	8.2	0.312
B4 Community Collaboration	0.253	7.5	0.251
B5 Cultural Dissemination	0.064	5.2	0.054

3.2. Model Validation and Case Adaptability

The model analysis reveals that "industrial integration" carries significant weight in the FAHP calculation, aligning with the findings from the DEMATEL causal network analysis. This further validates the feasibility of this strategy in fostering community co-construction through cultural and tourism IP development, such as the VR sailing experience project. Concurrently, DEMATEL findings reveal that "educational inheritance" functions as a subordinate element driven by other strategies. This aligns with the case's practical context where "school-enterprise collaboration must be grounded in industrial demand," illustrating the dynamic interdependence among strategies.

Combining the causal path "B3→B4" from DEMATEL further illustrates how industrial integration (B3) achieves concrete outcomes through the "VR Sailing Experience" project: with a total investment of approximately ¥1 million, the

project generated 20 new community jobs. Calculations yield a correlation coefficient of r = 0.78, indicating that industrial integration significantly promotes community co-construction. Based on the causal network results from DEMATEL, this paper proposes a "Core Strategy First—Feedback Iteration" implementation pathway. This approach prioritizes advancing core driving strategies such as industrial integration, while continuously optimizing their impact on community co-construction and educational heritage strategies through dynamic monitoring and periodic evaluation mechanisms.

4. Core Strategy and Implementation Path

Based on the comprehensive weighting order derived from the mixed model (industrial integration > community co-construction > educational inheritance), this section establishes an implementation mechanism centered on core driving strategies. This mechanism integrates execution pathways, resource coordination, and feedback evaluation, aiming to form a dynamically optimized strategy system for revitalizing Fujian's intangible cultural heritage.

4.1. Driven by Industrial Integration: From "Cultural Symbol" to "Economic Vehicle"

Industrial integration serves as the core strategy for revitalizing Fujian's intangible cultural heritage, with its key objective being the transformation from "cultural symbols" to "economic vehicles." Drawing inspiration from Suzhou-style furniture's cultural-tourism integration model and referencing the success of Suzhou Zhouzhuang's "Suzhou Craft Workshops" experiential project (annual revenue reaching 12 million yuan, with tourist participation increasing by 40%), this study proposes a cultural-tourism IP development pathway centered on "Fujian Ship Maritime Experience Tours" and "Intangible Cultural Heritage Artisan Workshops." The goal is to achieve revenue growth to 8 million yuan by 2025. Lin Peizong's team collaborated with Quanzhou's Culture and Tourism Bureau to establish a VR maritime simulation experience zone at the Maritime Silk Road Fuchuan Museum. During its 2023 trial operation, visitor numbers increased by 25% year-on-year, validating the significant boost cultural experience innovations provide to market appeal.

4.2. Digital Innovation: Technology-Empowered Living Heritage

Digital innovation has opened new technological pathways and dissemination methods for the living transmission of Fujian's intangible cultural heritage. Drawing on the successful experience of Suzhou-style furniture in 3D modeling and virtual exhibitions—Suzhou Vocational College of Arts and Crafts achieved over 500,000 online museum visits by digitally replicating Ming and Qing dynasty furniture——Fujian ships can leverage existing data resources from the Ningde Zhangwan Research Association to build a "Fujian Ship Digital Twin Platform." This platform integrates 3D models of 12 ancient vessels for VR immersive displays and structural disassembly instruction, advancing virtual preservation and educational dissemination of traditional craftsmanship.

At the technical implementation level, the Fujian Ship Culture Cooperative and Jimei University's School of Naval Architecture and Ocean Engineering jointly developed the "Fujian Ship Craftsman" app. Users can scan physical models to visualize dynamic demonstrations of watertight compartment structures. Two related invention patents have been filed. Simultaneously, leveraging the precision craftsmanship of Wuxi Xizhang Shipyard in 3D printing (with error rates controlled within 0.1 mm), an AR-based "Fujian Shipbuilding Simulation" course can be developed. This course will be integrated into the vocational college elective systems, forming a digital teaching chain encompassing "virtual construction—hands-on training—outcome display."Through the synergistic application of digital twins, AR/VR interactions, and mobile applications, the knowledge system of Fujian's intangible cultural heritage shipbuilding is visualized, made interactive, and sustainably transmitted in the digital space. This provides robust technical support for making traditional craftsmanship "teachable, learnable, and evolvable."

5. Conclusion

This study systematically reveals the strategy-driven chain of "industrial integration → community co-construction → educational inheritance" through a DEMATEL causal network based on a mixed model, thereby establishing a revitalization pathway for Fujian's intangible cultural heritage craftsmanship. Findings indicate that industrial integration and digital innovation serve as core priority strategies for Fuchuan revitalization, while community co-construction and educational inheritance form synergistic support mechanisms under their impetus. Future efforts should incorporate consumer demand data to refine a "dynamic adjustment-feedback optimization" mechanism, ensuring sustainable development in intangible cultural heritage revitalization.

At the policy level, governments, enterprises, and communities should establish collaborative governance mechanisms to transition Fuchuan culture from "static preservation" to "living innovation." Local governments should prioritize approving industrial integration projects (e.g., cultural tourism IP development) and establish a "Special Fund for Intangible Cultural Heritage Revitalization," encouraging increased social capital participation to 30%. Concurrently, a dynamic evaluation system should be established to monitor project performance in real-time through metrics like cultural and creative sales revenue and community participation rates. Big data analysis of visitor preferences (e.g., social media comment mining) should be leveraged to achieve precise iterative strategy matching.

It should be noted that this study has not yet incorporated empirical analysis of consumer preference data. Future research could integrate sentiment analysis methods for social media texts to optimize the alignment between strategies and market demand. Furthermore, the constructed model could be extended to other marine-related intangible cultural heritage projects to validate its universality and applicability.

Disclosure statement

The author declares no conflict of interest.

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