

Research on Living Heritage Transmission and Innovative Development of Yi Ethnic Embroidery Techniques: A Quantitative Exploration of Sustainable Development Pathways based on Innovation Models

Dingyu Wang*

School of Finance, Anhui University of Finance and Economics, Bengbu 233030, China

*3479525941@qq.com

Abstract: Yi embroidery is a national intangible cultural heritage of China and a vital vehicle for the living transmission of ethnic culture. Under modernization and marketization it faces a generational gap among bearers, rigidified techniques, product homogenization, and a weakening cultural core. This paper treats the sustainable development of Yi embroidery as a multidimensional assessment problem in which cultural, economic, and social subsystems are measured by an indicator system, weighted by an entropy procedure, aggregated into a composite index, and diagnosed by a coupling coordination model, while a logistic model describes the adoption of innovation models. Based on field research in Chuxiong, Liangshan, and Bijie, six innovation models are analyzed and regional sustainability is estimated. The level and the balance of sustainability differ across regions, faster adoption is linked to stronger economic sustainability, and no single model dominates. Five coordinated pathways spanning transmission, technique, industry, brand, and governance are proposed.

Keywords: Yi embroidery, intangible cultural heritage, living transmission, innovation model, sustainable development, coupling coordination.

1. Introduction

Yi embroidery is a national intangible cultural heritage of China, inscribed in 2008 on the second national list of representative items. It carries the historical memory, folk beliefs, and aesthetic wisdom of the Yi people, and the vitality of such heritage depends on its continuous transmission within contemporary life rather than on static preservation [1]. The craft comprises dozens of stitch techniques and motifs such as fire, tiger, and sun patterns that encode reverence for nature and ancestors [2].

Cultural economics holds that creative cultural assets possess both cultural and economic value, and that suitable institutions can convert the former into the latter without eroding it [3]. In the core regions of Chuxiong in Yunnan, Liangshan in Sichuan, and Bijie in Guizhou, Yi embroidery has become a distinctive rural industry. Yet under modernization and marketization it confronts a generational gap among bearers, rigidified techniques, product homogenization, and a weakening cultural core. Sustainable development requires meeting present needs without compromising those of future generations [4], which for intangible heritage means the joint pursuit of cultural, economic, and social sustainability.

Innovation models have emerged in practice, and their spread among bearers follows the dynamics of the diffusion of innovations [5]. However, existing studies usually examine a single model in isolation, often through design translation studies [6] or qualitative strengths and weaknesses analyses [7], and seldom assess how multiple models jointly shape sustainability across regions. This paper builds a quantitative assessment framework, analyzes six innovation models, estimates regional sustainability, and proposes integrated development pathways.

These three lenses, cultural economics, diffusion theory, and sustainable development, are mutually reinforcing rather than independent. Cultural economics explains why creative assets can earn a market premium while remaining cultural, diffusion theory explains how new productive arrangements spread among bearers, and sustainability theory explains why short term commercial gains must not erode the cultural base that gives the craft its premium in the first place. Reading these three traditions together motivates the quantitative framework adopted here, in which the cultural, economic, and social subsystems are not aggregated into a single bottom line but are tracked separately and then combined through a coupling coordination procedure that penalizes imbalance. The framework therefore makes the trade-off between cultural retention and commercial scaling legible rather than hidden inside an aggregate score, which is the central requirement for policy design in the intangible heritage setting.

The contribution of this paper is therefore threefold. First, it constructs an indicator system for Yi embroidery that operationalizes the three sustainability subsystems through twelve measurable variables and assigns weights endogenously by entropy, removing the subjectivity of expert scoring. Second, it computes a coupling coordination degree alongside the composite index, enabling diagnosis of whether a region is high but unbalanced, balanced but low, or balanced and high. Third, it interprets the rollout of the six innovation models through a logistic diffusion curve fitted to county-level adoption counts, which yields comparable saturation levels and diffusion rates across regions and across models and brings the dynamic dimension of heritage industries into the same quantitative space as the static indices. The remainder of the paper is organized as follows. Section II describes the six innovation models. Section III sets out the assessment framework. Section IV reports the empirical

results for Chuxiong, Liangshan, and Bijie. Section V derives the pathways. Section VI concludes.

2. Innovation Models

Field research in the three core regions identified six innovation models. Their characteristics are summarized in Table 1.

The inheritor and workshop model centers on bearers who run rural workshops and transmit skills through a master and apprentice arrangement. It retains culture well but operates at small scale with low value added. The government, enterprise, and cooperative model relies on government coordination, enterprise market operations, and cooperative organization within an industrial park, achieving scale but at times favoring commerce over heritage. The university, designer, and embroiderer model reinterprets traditional elements to raise creativity and value, although the collaborations are often short term.

The digital empowerment model widens sales channels and improves design efficiency, and generative methods can regenerate Yi motifs while retaining ethnic identity [8], though motif simplification is a risk. The cultural tourism model integrates embroidery into visitor experiences, as documented for Meigu County in Liangshan [9], but suffers from homogenization and seasonality. The cross sector branding model collaborates with established brands to reshape product forms, achieving brand elevation while high quality collaboration resources remain scarce.

These six models are not mutually exclusive, and in every county studied they coexist in varying proportions. The inheritor and workshop model anchors the cultural subsystem because it preserves the master and apprentice relationship through which the tacit knowledge of stitch techniques is transmitted across generations, and it is the only configuration

in which the full inventory of historical motifs is reliably reproduced. The government, enterprise, and cooperative model anchors the economic subsystem because only this configuration commands the capital and the coordinating authority needed to standardize procurement, enforce quality control across hundreds of dispersed producers, and negotiate access to mainstream retail channels. The remaining four models then act as supplements that improve a specific weakness: the university, designer, and embroiderer model lifts product value added through redesign, the digital empowerment model widens market reach without requiring physical retail expansion, the cultural tourism model creates a non-product revenue stream that monetizes the cultural narrative directly, and the cross sector branding model raises brand equity by borrowing the prestige of established partners.

Three trade-offs run across the six models and motivate the quantitative diagnosis. The first is between cultural retention and economic scalability: models centered on bearers retain stitches and motifs faithfully but cannot scale, while industrially organized models scale rapidly but tend toward motif simplification and stitch substitution as cost pressures intensify. The second is between specialization and diffusion: models that depend on scarce assets such as a famous brand partner or a top tier design school cannot be replicated widely and therefore deliver high returns to a small number of firms while leaving most producers untouched. The third is between stability and adaptability: workshop and cooperative arrangements are organizationally stable but slow to refresh designs in response to market signals, whereas digital and cross sector arrangements adapt quickly but depend on partners outside the bearer community whose interest may not persist. These trade-offs explain why no single model dominates and why the relevant policy question is how to combine models so that their strengths are additive rather than redundant.

Table 1. The six innovation models and their principal characteristics.

Model	Lead actor	Cultural retention	Economic scalability	Principal limitation
Inheritor and workshop	Bearer	High	Low	Small scale and low value added.
Government, enterprise, cooperative	Government	Medium	High	Commerce over heritage.
University, designer, embroiderer	University	Medium	Medium	Unstable collaboration.
Digital empowerment	Platform	Medium	High	Motif simplification risk.
Cultural tourism integration	Operator	Medium	Medium	Homogenization and seasonality.
Cross sector branding	Brand	Medium	High	Scarce collaboration resources.

3. Assessment Model and Method

Let there be n regions indexed by i and m indicators indexed by j . Each indicator is normalized to the unit interval by equation (1) for positive indicators.

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \quad (1)$$

where $x_j^{\min}$ and $x_j^{\max}$ are the minimum and maximum of indicator j . To avoid subjective weighting, the entropy weight method from information theory is used [10]. With the

proportion p_{ij} of indicator j contributed by region i , the information entropy and the weight are given in equations (2) and (3).

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^n p_{ij} \ln p_{ij} \quad (2)$$

$$w_j = \frac{1 - e_j}{\sum_{k=1}^m (1 - e_k)} \quad (3)$$

The composite sustainability index aggregates the three subsystem utilities, where U_i^s equals $\sum_{j \in \Omega_s} w_j r_{ij}$ for

subsystem s and λ_s is the subsystem weight, as in equation (4).

$$S_i = \sum_{s=1}^3 \lambda_s U_i^s \quad (4)$$

A high index can still mask imbalance, so the coupling coordination model is adopted [11]. The coupling degree is defined in equation (5), and the coupling coordination degree in equation (6), where T is the comprehensive coordination index equal to the weighted sum of the subsystem utilities.

$$C = 3 \sqrt[3]{\frac{U^{cul} U^{eco} U^{soc}}{(U^{cul} + U^{eco} + U^{soc})^3}} \quad (5)$$

$$D = \sqrt{C \cdot T} \quad (6)$$

Finally, the adoption of an innovation model is described by a logistic model whose solution is given in equation (7), where $N(t)$ is the cumulative number of adopters, K is the saturation level, r is the diffusion rate, and N_0 is the initial number of adopters; this form is equivalent to the diffusion model for new products [12].

$$N(t) = \frac{K}{1 + \frac{K - N_0}{N_0} e^{-rt}} \quad (7)$$

Three design choices deserve comment. First, the indicator system uses only variables that can be observed during a county-level field visit or read from official annual reports, which keeps the framework replicable in regions where firm level accounting is unavailable and avoids the survivorship bias that arises when only well documented enterprises are

sampled. Second, the entropy weighting procedure has the desirable property that an indicator carries more weight when its values are more dispersed across regions, since dispersed indicators discriminate better and therefore inform the composite more usefully than indicators on which all regions look alike. Third, the coupling coordination model used in equations (5) and (6) is preferred over a simple geometric mean because the coupling degree C captures the degree to which the three subsystems move together while the comprehensive coordination index T captures their joint level, and their product D combines the two concerns into a single number that ranges over the unit interval and is straightforward to compare across regions and time periods.

Following common practice in the coupling coordination literature, D values in the intervals from zero to 0.4, from 0.4 to 0.5, from 0.5 to 0.7, from 0.7 to 0.8, and from 0.8 to 1.0 are interpreted as serious imbalance, mild imbalance, basic coordination, intermediate coordination, and good coordination, respectively. The logistic adoption curve in equation (7) is fitted separately for each innovation model in each region by minimizing the squared error between the observed cumulative number of adopters and the predicted number. The estimated saturation level K is interpreted as the long-run carrying capacity of the model in the region, and the estimated diffusion rate r is interpreted as the speed of uptake among potential adopters. These two parameters then enter the discussion in Section IV alongside the static sustainability indices and allow a joint reading of the level of sustainability and the speed at which innovation models are spreading.

4. Empirical Results

The analysis draws on three months of field research across nine counties in Yunnan, Sichuan, and Guizhou, with twelve representative cases. The indicator system and the entropy weights are reported in Table 2, where annual output value and per capita income carry the largest weights.

Table 2. Indicator system and entropy weights.

Subsystem	Indicator	Weight
Cultural	Inheritors per ten thousand population	0.082
	Number of retained core stitch techniques	0.071
	Density of workshops and training centers	0.068
	Cultural symbol retention rate	0.091
Economic	Annual output value	0.103
	Per capita income of embroiderers	0.088
	Industrial chain completeness	0.079
	Product value added rate	0.085
Social	Employment driven scale	0.094
	Youth participation rate	0.083
	Poverty household coverage	0.061
	Market and channel reach	0.095

Using these weights, the subsystem utilities, composite index, and coupling coordination degree were computed for the three regions, as reported in Table 3. Chuxiong attains the

highest composite index S_i and good coordination, followed by Liangshan, while Bijie is lower owing to a weaker economic subsystem U^{eco} . Across the three regions the

annual output value is about 2.86 billion yuan, employing about 173 thousand embroiderers and raising the average

annual income by about eleven thousand yuan, which corroborates the role of the craft in rural revitalization [13].

Table 3. Subsystem utilities, composite sustainability index, and coupling coordination degree by region.

Region	U^{cul}	U^{eco}	U^{soc}	S_i	D	Coordination grade
Chuxiong (Yunnan)	0.780	0.810	0.760	0.784	0.885	Good coordination
Liangshan (Sichuan)	0.710	0.690	0.670	0.690	0.831	Good coordination
Bijie (Guizhou)	0.660	0.490	0.600	0.580	0.760	Intermediate coordination

The pattern in Table 3 is consistent with the qualitative profiles of the three regions. Chuxiong has the longest history of policy support and the densest concentration of industrial-park infrastructure, which lifts both the economic subsystem and the social subsystem through stable employment for embroiderers, and its coupling coordination degree D of 0.885 places it in the good coordination band at the upper end of the scale. Liangshan has a comparable cultural base but a narrower economic base, which yields a slightly lower composite index of 0.690 yet still reaches good coordination because the three subsystems move together rather than diverging. Bijie has fewer industrial-park resources, which depresses the economic utility to 0.490 and pulls the region into the intermediate coordination band even though its cultural utility is only modestly below Liangshan, indicating that the binding constraint in Bijie is the economic subsystem rather than the cultural base.

Fitting the logistic adoption curve of equation (7) to county-level data for the six models yields estimated diffusion rates that vary by an order of magnitude across models within the same region. In Chuxiong the government, enterprise, and cooperative model reaches a high estimated saturation level with a moderate diffusion rate, while the cross sector branding model reaches a lower saturation level but with a faster diffusion rate among the small set of firms that can attract brand partners. In Liangshan the cultural tourism integration model has the highest fitted saturation level because the region combines a strong tourism base with a recognizable cultural narrative, while in Bijie the digital empowerment model has the highest fitted diffusion rate, which suggests that digital channels are the most accessible entry route for regions lacking industrial-park infrastructure and therefore the most promising lever for raising the economic utility in the short term.

Two cross-cutting observations emerge from the twelve case studies. First, regions in which more than two innovation models had crossed the inflection point of the logistic curve recorded higher coupling coordination degrees than regions dominated by a single model, which supports the central argument that model integration matters as much as model choice and that the marginal return to adding a complementary model is larger when the existing portfolio is narrow. Second, the cultural symbol retention rate, which carries the largest weight within the cultural subsystem at 0.091, is the indicator most sensitive to commercial scaling, and several cases showed that this indicator declined as the economic indicators rose, signaling the trade-off that the pathways in Section V are designed to manage through binding rules on protected motifs and stitches rather than through voluntary appeals to cultural responsibility.

5. Pathways and Discussion

Five mutually reinforcing pathways follow from the results.

First, a tiered transmission system extends heritage education into schools and attracts returning talent. Second, cultural authenticity is balanced with modern innovation by preserving core stitches while reconstructing traditional elements. Third, the full industrial chain is optimized through shared procurement, standardized production, and stable collaboration, which strengthens the economic subsystem and lifts coordination. Fourth, a tiered brand system combines a regional public brand with local cultural identities. Fifth, a multi actor governance mechanism consolidates fragmented policies and diversifies funding.

The five pathways translate into concrete instruments that can be calibrated to the diagnosis of each region. The tiered transmission pathway combines compulsory primary school exposure to embroidery culture, elective secondary school courses, vocational diploma tracks, and an undergraduate workshop track linked to design schools, together with a returning talent scheme that offers seed grants and housing subsidies to young embroiderers who establish workshops in their home counties. This pathway addresses the youth participation indicator directly and reinforces the inheritor and workshop model that anchors the cultural subsystem, which the empirical results in Section IV identify as the binding constraint on long term cultural retention even in regions with strong economic indicators.

The authenticity and innovation pathway operates through a documented inventory of core stitches and protected motifs that any commercial product carrying a regional certification must respect, paired with an open design library that permits modern reinterpretation of secondary decorative elements. The industrial chain pathway is implemented through shared procurement cooperatives that lower input costs, regional quality standards that reduce dispersion in product value added, and stable multi-year contracts between design houses and workshops that overcome the short termism of one-off collaborations. The tiered brand pathway distinguishes a regional public brand for general market communication, county level cultural identities for differentiation, and firm level brands for cross sector projects, so that the three brand layers reinforce rather than dilute one another and a single failure at one level does not damage the others.

The multi actor governance pathway consolidates fragmented policies into a medium term plan that aligns transmission funding, industrial subsidies, and tourism investments around the same set of indicators used in the assessment framework, and it broadens funding by combining fiscal grants with social capital and patient impact finance. Three risks must be managed in implementation. The first is the risk that policy attention concentrates on indicators that are easy to measure and neglects qualitative cultural transmission, which can be mitigated by reserving a fixed share of evaluation weight for indicators that require field verification. The second is the risk that brand elevation

outpaces production capacity and erodes credibility through quality failures, which can be mitigated by tying brand expansion to certified output volume. The third is the risk that digital channels accelerate motif simplification, which can be mitigated by certification rules that tie online listings to the protected motif inventory.

The framework is not specific to Yi embroidery and can be transferred to other ethnic handicrafts that face a similar tension between cultural retention and commercial scaling, as shown by comparable sustainable design work on Miao embroidery [14]. The main limitations are the focus on core regions and the limited horizon, so the weights and parameters reflect current conditions more than long term trends.

6. Conclusion

This paper treated the living transmission and innovative development of Yi embroidery as a multidimensional sustainability assessment problem and combined an entropy weighted composite index, a coupling coordination diagnosis, and a logistic diffusion model. Field research supported the analysis of six innovation models and the estimation of regional sustainability. The level and the balance of sustainability differ across regions, faster adoption is linked to stronger economic sustainability, and no single model dominates, so model integration is the central lever. Five coordinated pathways spanning transmission, technique, industry, brand, and governance were proposed. Future work will extend the framework to secondary regions and add long term tracking to validate the pathways.

Three broader implications follow. First, the joint use of an entropy weighted composite index and a coupling coordination diagnosis is a useful template for any intangible heritage that must reconcile cultural retention with commercial scaling, since it makes the trade-off legible and provides a metric for adjudicating policy choices rather than leaving the decision to qualitative judgment. Second, the diffusion of innovation models is itself a policy lever rather than a passive process, because the saturation level and the diffusion rate respond to the same instruments that shape the static sustainability indices, and an integrated policy can therefore target both the level and the speed of change. Third, the regional variation documented for Yi embroidery in Yunnan, Sichuan, and Guizhou demonstrates that a single national policy is unlikely to be optimal and that diagnostic frameworks of the kind proposed here are necessary precisely because the binding constraint differs across regions.

Future work should extend the framework along three directions. The first is a longitudinal dataset that tracks the twelve indicators annually for at least five years and supports causal identification of policy effects through difference in differences or synthetic control methods. The second is an expansion to secondary regions including Pu'er in Yunnan and Panzhihua in Sichuan to test the external validity of the entropy weights and the coupling coordination thresholds. The third is a comparison with parallel datasets on other ethnic embroidery traditions in southwest China, which would refine the framework into a general tool for living heritage assessment and clarify which features of the Yi case

are specific and which are common to the broader category of textile-based intangible heritage.

Acknowledgments

This work was supported by the Undergraduate Research Innovation Fund of Anhui University of Finance and Economics under Grant XSKY25086.

References

- [1] UNESCO. (2003). *Convention for the safeguarding of the intangible cultural heritage*. UNESCO.
- [2] Wang, J. (2026). Artistic features and modeling rules of embroidery patterns in Yi traditional costumes. *Progress in Textile Science and Technology*, 1-9. <https://doi.org/10.19507/j.cnki.1673-0356.20260312.003>. (In Chinese)
- [3] Throsby, D. (2001). *Economics and culture*. Cambridge University Press.
- [4] World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.
- [5] Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
- [6] Liu, Y., Li, H., & Zhang, X. (2026). Translation and innovation of Yunnan Yi embroidery in modern cultural and creative design. *Culture Journal*, (2), 70-73. (In Chinese)
- [7] Jiang, Z., Zhang, W., Li, F., et al. (2026). New quality productive forces empowering the industrialization of ethnic handicrafts: A SWOT analysis and development path of Yi embroidery in Y township, Eshan County. *Tian Gong*, (6), 13-16. (In Chinese)
- [8] He, L. (2025). Database construction and remodeling method on traditional Yi nationality patterns of China with GAN model. *npj Heritage Science*, 13(1), 181. <https://doi.org/10.1038/s40494-025-01707-w>
- [9] Peng, S. (2023). Tourism commercialization development strategy of Liangshan Meigu Yi embroidery. *West Leather*, 45(22), 28-30. <https://doi.org/10.20143/j.1671-1602.2023.22.008>. (In Chinese)
- [10] Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, 27(3), 379-423. <https://doi.org/10.1002/j.1538-7305.1948.tb01338.x>
- [11] Huang, J., Shen, J., & Miao, L. (2021). Carbon emissions trading and sustainable development in China: Empirical analysis based on the coupling coordination degree model. *International Journal of Environmental Research and Public Health*, 18(1), 89. <https://doi.org/10.3390/ijerph18010089>
- [12] Bass, F. M. (1969). A new product growth model for consumer durables. *Management Science*, 15(5), 215-227. <https://doi.org/10.1287/mnsc.15.5.215>
- [13] Liu, C. (2025). Development and innovation path of weaving and embroidery intangible cultural heritage and rural revitalization: A case study of Mabian Yi embroidery in Sichuan. *Tomorrow Fashion*, (23), 142-144. (In Chinese)
- [14] Wang, J. (2025). Sustainable design on intangible cultural heritage: Miao embroidery pattern generation and application based on diffusion models. *Sustainability*, 17(17), 7657. <https://doi.org/10.3390/su17177657>