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Place-Based Divergence in Sustainable Textile Material Selection: A Comparative Study of China, Japan, Italy, and Finland

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Abstract: The global textile industry faces an imperative shift towards sustainability, yet practices diverge significantly across regions, particularly in the choice of materials. This study investigates how and why sustainable textile material selection varies between distinct socio-industrial contexts. Employing a comparative case study methodology, it analyzes China, Japan, Italy, and Finland through systematic coding of secondary data. Findings reveal four distinct, coherent material selection logics: trade-off decision-making in China driven by scalability, authenticity logic in Japan rooted in craft tradition, value maintenance logic in Italy centered on quality equivalence, and lifecycle judgment logic in Finland premised on ecological innovation. Synthesizing these, the study proposes a Place-based Framework, conceptualizing material selection as a contextualized judgment process shaped by the interaction of six dimensions: resource ecology, craft-technology pathways, industrial logic, cultural values, design decision-making, and sustainability orientation. Furthermore, an exploratory collaboration model derived from the framework demonstrates varied complementarity and conflict risks across regional pairs. This research provides a structured lens to understand regional pathways in sustainable transition and offers practical insights for fostering cross-regional collaboration based on complementary logics rather than standardized solutions.

Keywords: sustainable textiles; material selection; regional comparison; place-based framework; circular economy; cross-regional collaboration

1. Introduction

1.1. Background and Research Motivation

The textile and apparel industry is a vital global economic sector yet is also widely recognized as one of the most resource-intensive and polluting, making its transition to sustainable models an urgent worldwide imperative [1]. Within this transition, material selection occupies a central role, directly determining the environmental footprint of a product throughout its life cycle. However, a compelling phenomenon is observed: despite shared sustainability goals, practitioners across different world regions exhibit profound and systematic variations in selecting and applying what constitutes sustainable textile materials [2]. For instance, European contexts often emphasize recycled fiber systems underpinned by standardized certifications and quantitative assessments like Life Cycle Assessment (LCA), whereas many Asian regions show a stronger inclination towards utilizing natural or agricultural by-product fibers deeply integrated with local farming and craft traditions [3,4]. This divergence suggests that the sustainability transition is not a process of seeking and disseminating a singular technical

optimal solution, but rather a socio-technical process embedded within place-specific conditions [5].

As global value chains and design concepts become increasingly fluid, actors in the textile industry from designers and manufacturers to brands, are increasingly situated within a complex network where local traditions intersect with global markets [6]. This makes understanding regional differences critical. An essential question must be addressed: When sustainability is endowed with different meanings and practical pathways across local contexts, how can we systematically understand these differences? Furthermore, how can these differences be transformed into complementary assets for global industry collaboration, rather than remaining as barriers?

1.2. Limitations of Existing Research

The existing body of research on sustainable textiles is substantial. One stream focuses on material science and technological innovation, developing novel fibers with superior environmental performance; another investigates regional practice differences from perspectives such as consumer behavior, cultural values, or policy comparison [7,8]. Nevertheless, significant gaps remain.

Firstly, much of the discourse still implicitly adopts the technical standards and experiences of the Global North as the primary reference frame. There is a lack of systematic, integrated analysis of the inherent place-based systems that shape material selection decisions in different regions encompassing unique resource endowments, historically formed craft regimes, industrial structures, cultural values, and design methodologies [9]. Material selection is often reduced to a technical or economic decision based on universal environmental metrics, overlooking its profound context-dependency.

Secondly, even when studies note regional differences, they frequently remain at the level of phenomenological description or explanation via single factors. They fail to theorize the underlying generative logic behind these differences into a comparable analytical framework. Consequently, we cannot adequately explain: why do distinctly different solutions emerge in various regions facing similar sustainability challenges? What are the structural underpinnings of these solutions?

Finally, stemming from the above understanding gap, research on how to facilitate effective collaboration across different regions is particularly scarce. Most proposals for global sustainable textiles still imply a logic of best practice diffusion, lacking a collaborative perspective grounded in local knowledge and complementary advantages.

1.3. Research Objectives and Contributions

To address these research gaps, this study aims to conduct a structured comparative case analysis to explore the following three core research questions:

What specific patterns of difference characterize sustainable textile material selection in four representative regions: China, Japan, Italy, and Finland?

How are these divergent patterns generated and sustained within their respective place-based systemic conditions?

Based on an understanding of these differences and their generative logic, what potential synergistic pathways exist for collaboration between these regions?

To achieve these objectives, the study employs a comparative case study methodology, systematically analyzing multi-source secondary data from academic, industrial, and policy domains. The primary contribution of this research is twofold. Theoretically, it not only identifies four dominant place-based material selection logics including trade-off decision-making, authenticity logic, value maintenance logic, and life-cycle Judgment Logic, but further proposes an integrative Place-based Systemic Framework. This framework conceptualizes sustainable material selection as a contextualized judgment process shaped by the interactions among six dimensions: Resource Base, Craft-Technology Pathway, Industrial Logic, Cultural Value, Design Decision Logic, and Sustainability Orientation. Practically, the exploratory cross-regional collaboration model developed based on this framework aims to provide industry

practitioners and policymakers with a new approach to collaboration centered on complementarity and systemic compatibility, rather than the standardized dissemination of practices.

2. Literature Review

2.1. Global Perspectives on Sustainable Textile Material Selection

In recent years, sustainable research in the global textile industry has expanded from early-stage material innovation and efficiency assessment to incorporate concerns about differentiated regional practices [10]. However, a significant Global North centricity persists in the prevailing academic discourse. Its research paradigms, evaluation standards, and proposed solutions are often tacitly assumed to be universal templates [11]. This perspective tends to treat sustainability as a decontextualized technical issue, resulting in studies that, while offering macro-level strategies or unified metrics, prove inadequate in addressing the fundamental disparities among regions regarding material accessibility, processing infrastructure, and industrial realities [12]. For instance, a comparative study across multiple regions notes that practices in the Global North rely more on technology and system integration, whereas those in many Global South contexts are more deeply rooted in local economies and traditional craft pathways [13]. While such research reveals structural differences, its focus often remains on overall development models, leaving a lack of systematic, design-oriented analysis regarding how materials themselves are specifically selected, processed, and applied within distinct production contexts [14].

Concurrently, discussions on regional variation frequently unfold through lenses such as consumer behavior or cultural perception [15]. Although these studies enrich our understanding of the market demand side, most fail to treat material availability at the production end, craft compatibility, and modes of embedding within industrial chains as core analytical dimensions. Consequently, a key gap in current research is the lack of contextualized, cross-regional systematic comparison of the concrete practice of sustainable textile material selection. This limitation hinders a deeper understanding of the diverse pathways within the global sustainability transition and obstructs the identification of complementarity potential based on these differences.

2.2. Regional Differences in Sustainable Textile Material Practices

Marked contrasts in the actual selection of sustainable materials have already emerged across different regions, primarily reflected in material sources and types. Practices in Europe particularly Nordic and Western Europe are highly reliant on certification systems and circular economy policies, promoting materials with clear origins and quantifiable metrics, such as organic cotton, recycled polyester, and wood-based fibers like Spinnova® into the mainstream [16]. Their discourse on sustainability is tightly coupled with standardized, traceable industrial systems. In contrast, across many Asian regions, sustainable material practices are deeply embedded within local resource systems and cultural traditions [17]. For example, research in China often focuses on indigenous plant fibers like bamboo and ramie, as well as agricultural by-products; Japan emphasizes materials co-evolved with traditional crafts, such as silk and washi (paper) fibers; in Southeast Asia, fibers like pineapple leaf are utilized to innovate local batik craftsmanship [18]. The primary logic behind selecting these materials is their congruence with local ecology, agricultural systems, and cultural identity, rather than prioritizing compliance with international certification standards [19].

Secondly, regional divergence manifests in the evaluation priorities of sustainability. European research widely employs quantitative tools like LCA and carbon footprinting, pursuing the datafication and comparability of environmental performance [20]. In some East and Southeast Asian contexts, evaluation places greater emphasis on the resource availability of materials, feasibility of local processing, and their contribution to local communities and craft heritage [21,22]. This difference does not signify conflicting goals

but reflects the distinct prioritization that different place-based systems assign to the multiple dimensions of sustainable development.

2.3. *The Influence of Craft Practices and Production Conditions on Material Selection*

Material selection is never an isolated decision but is deeply coupled with local craft systems and production conditions. Specific craft techniques impose definite requirements on the physical properties of fibers, which have historically shaped regional material preferences [23]. Examples include the compatibility between Japanese traditional indigo dyeing (aizome) and cotton fiber, or the reliance on fiber elasticity for hand-weaving wool in the Andes [24]. These material-craft pairings constitute the core of local knowledge systems.

In contemporary settings, production conditions further mediate the influence of craft on material selection. In regions dominated by industrial production, the successful introduction of any new material hinges on its ability to seamlessly integrate into existing high-speed, standardized spinning, weaving, and dyeing chains without costly equipment retrofitting. This leads to a preference for innovative materials whose performance is highly compatible with traditional ones. Conversely, in regions characterized by craft or semi-industrial production, material selection is more directly linked to the viability of low-energy processing methods, specific craft knowledge, and small-scale production networks [25]. For instance, the persistence in using plant-dyed ramie fabrics in parts of China is inseparable from its production context of low-chemical, segmented manual handling [26].

However, current research on craft and production conditions tends to be polarized: it either treats them as static cultural heritage symbols, detached from contemporary production realities, or reduces them to neutral technical processing steps, overlooking the differences in the underlying knowledge systems and social networks [27,28]. Research on how craft systems interface with modernized industrial structures is particularly scarce, yet this interface is crucial for understanding whether a material choice can transition from possible to feasible.

2.4. *Design Decision-Making in Sustainable Material Selection*

At the design stage, material selection is directly influenced by design strategies and methodologies. Different design approaches, by setting varied objectives and evaluation criteria, guide designers to focus on different types of materials [29]. For example, Eco-Design typically centers decision-making on LCA data, favoring materials with clear environmental metrics; whereas Material-Driven Design starts from the inherent properties and sensory experience of materials for experimental exploration, opening application avenues for many non-standardized local materials [30]. Furthermore, Speculative Design may employ materials as mediums to express socio-cultural issues, with selection criteria entirely different from environmental performance optimization [31].

Notably, the routine adoption of specific design methods varies by region, which further shapes the characteristics of material research and application. European industrial and academic research more commonly integrates the Eco-Design framework with quantitative tools; Japanese design practice more frequently employs Material-Driven Design to explore the contemporary potential of local traditional materials [32]. This divergence in design culture leads academic and industrial discussions in different regions to naturally focus on distinct categories of materials, thereby reinforcing existing regional pathways of material selection.

Although existing research points to the connection between design and material selection, the deep-seated systemic reasons for why differentiated design strategies emerge across regions remain largely unexplained. The persistence of this design strategy divergence in the context of globalization suggests the powerful shaping force of place-based systems. However, most current studies remain at the level of describing what is chosen, failing to adequately explain the structural logic of why it is chosen this way.

3. Methodology

3.1. Research Design

To deeply investigate the place-based generative logic behind sustainable textile material selection and systematically answer the how and why questions, this study employs comparative case study as the core research methodology [33]. This approach is particularly suited to investigating the manifestations of complex social phenomena within their real-life contexts, especially when the research focuses on the interplay between contemporary events and their specific settings, and the researcher has little to no control over the contextual conditions [34]. The core of this study lies in understanding how the material selection logic in different regions is formed within their specific socio-technical systems. Through systematic cross-case comparison, we can identify correspondences between different place-based system configurations and material selection patterns while preserving the integrity and complexity of each case. This allows the research to move beyond description of single locales and distill a more generally explanatory analytical framework [35].

3.2. Case Selection

Case selection follows the principle of maximum variation sampling from qualitative research [36]. The purpose is not to obtain a statistically representative sample but to conduct an in-depth comparison between cases that exhibit significant differences on key dimensions. This strategy highlights the range of variation of the phenomenon under different conditions and powerfully reveals underlying explanatory mechanisms [37].

Based on this principle, this study selects China, Japan, Italy, and Finland as the four analytical units. These four countries possess distinct characteristics in terms of resource base, craft traditions, industrial structure, and sustainability transition pathways, forming a comparative matrix rich in theoretical tension:

1) China represents a context with a vast domestic consumer market, a complete large-scale industrial system, where the sustainability transition is strongly driven by industrial feasibility and market acceptance [38].

2) Japan represents a context where craft systems are deeply embedded in cultural values, domestic production scale is shrinking, yet a strong product life extension culture exists. Material selection is strongly linked to craft authenticity and cultural continuity [39].

3) Italy represents a context centered on high-end luxury supply chains, regional industrial clusters, and Made in Italy quality aesthetics, where sustainability needs to be embedded within the existing value system [40].

4) Finland represents a context built on forest resources, leading in material science innovation but with limited domestic manufacturing scale, where sustainability orientation is highly prerequisites and emphasizes ecological transparency [41].

These four distinctly different place-based systems provide an ideal empirical foundation for examining and constructing the theoretical framework of how material selection logic varies by context.

3.3. Data Collection and Country Profile Construction

The data for this study derives from the systematic collection and analysis of multiple sources of secondary data. Primary data types include: 1) Academic literature including relevant journal articles, monographs, and dissertations in Chinese, English, Japanese, Italian, and Finnish; 2) Industry and policy reports containing government documents, industry white papers, think tank research reports; 3) Design practice texts such as brand sustainability reports, designer interviews, exhibition catalogues, case studies from professional media; 4) Material innovation institution materials involving corporate technical white papers, R&D institution website information. Using secondary data enables systematic retrospection and comparison of long-term practices and discourses across the four regions, overcoming geographical and linguistic barriers [42].

The core output of data collection is the construction of a structured Country Profile for each case. The profile content is systematically organized around six predetermined analytical dimensions: Resource Ecology, Craft-Technology Pathway, Industrial Structure, Cultural Values, Design Decision Logic, and Sustainability Orientation. These six dimensions, derived from the literature review, form the operationalized framework for understanding the place-based system. Through systematic synthesize and archiving, each case's profile forms a rich qualitative textual corpus, providing a solid empirical foundation for subsequent coding and comparison [43].

3.4. Data Analysis: Comparative Analysis and Coding

Data analysis employs a qualitative comparative method centered on thematic analysis, involving three main steps:

1) Open Coding. Initially, each Country Profile is read in-depth to identify and label any text segment related to material selection, evaluation, or judgment [44]. The coding process is inductive, not presupposing categories but generating initial tags from the data itself [45]. A single text segment can be assigned multiple codes to capture the intertwining of decision factors.

2) Cross-Case Comparison and Theme Development. After initial coding, a systematic comparison is conducted across the four cases. The focus is on identifying: a) which judgment dimensions are commonly present across different cases; b) the systematic differences in the relative importance, priority order, and combination patterns of these dimensions among cases. Through constant comparison and categorization, dispersed codes are clustered into several stable thematic material selection logics.

3) Framework Synthesis. Finally, the distilled core material selection logics are interactively analyzed with the place-based system dimensions containing resources, craft, industry, culture, design, sustainability orientation that generate them. This aims to reveal how specific system configurations tend to give rise to specific material judgment logics, thereby constructing the Place-based Systemic Framework proposed in this study. Based on this framework, the potential complementary and conflicting relationships between different logics are further deduced, forming the cross-regional collaboration analysis model.

4. Results and Discussion

4.1. Key Differences in Sustainable Textile Material Selection Across the Four Regions

Based on the systematic coding and comparative analysis of the Country Profiles, China, Japan, Italy, and Finland exhibit clear and systematic patterns of difference in sustainable textile material selection. Table 1 synthesizes these differences across core dimensions.

Table 1. Cross-Regional Comparison of Sustainable Textile Material Selection.

Dimension / Region	Preferred Materials Examples	Resource Base	Manufacturing Structure	Sustainability Emphasis	Regional Specificities
China	Cotton, regene	Diversified resour	Large-scale, cost-	Implementability & Scalability	Aesthetic risk and market

	rated cellulose fibres, bamboo fibre, ramie fibre	ces; ample regenerated cellulose feedstock	sensitive, highly integrated supply chains	; achieved via process-level optimization within existing systems	acceptance limit adoption; innovation often incremental
Japan	Silk, cotton, washi (paper) fibre, indigo & other plant-based dyes	Local natural fibres; natural dyes	Small-scale, artisanal, culturally embedded textile practices	Embedded through repair, reuse, and long-life use culture	Weak recycling infrastructure; high import dependency; shrinking domestic production
Italy	Wool, silk, high-end blended fibres	High-quality raw materials; premium fibres; refined finishing	Cluster-based SME networks; highly specialised processing	Integrated through premium quality, traceability, and brand-narrative value; policy-driven circularity	SME-dominated system struggles to scale recycling; uneven digital & circular practice adoption
Finland	Wood-based cellulose fibres forming a bio-based material ecosystem	Forest-based cellulose ecosystem; biomaterial innovation	Weak domestic manufacturing capacity; export-linked	Emhasis on transparency, material simplicity, and ecological metrics	Insufficient waste volume for economies of scale; slow digital uptake; EU-dependent feedstock

Trade-off Decision-Making in China occurs under conditions of highly accessible resources and manufacturing capacity, demonstrating a distinct trade-off decision logic. Sustainability is not the sole or primary driver but must be intricately balanced against

feasibility for mass production, cost control, supply chain stability, and end-market acceptance, particularly the aversion to aesthetic risk [46]. Consequently, materials like regenerated cellulose fibres, which align with vast existing production capacities while offering environmental benefits, see widespread adoption. Distinctive natural fibres like bamboo and ramie seek their balance within differentiated niche markets. Sustainable practice manifests as incremental optimization and embedded adaptation of the incumbent system.

Authenticity Logic in Japan is tightly coupled with its profound craft traditions and cultural context, following an authenticity logic. The value of a material lies not only in its physical properties but also in its symbolic meaning and emotional connection as a cultural carrier and medium for craft. The continued use of silk, washi fibre, and plant dyes reflects a commitment to genuine materials and traditional skill and art. Facing structural challenges of shrinking domestic production and high import dependency, Japan's sustainability pathway emphasizes extending the use phase of products through repair, alteration, and second-hand circulation, embedding sustainability within cultural practices and life philosophy rather than pursuing the industrial efficiency of material recycling.

Value Maintenance Logic in Italy is shaped by its luxury brand-dominated high-end industrial system, centered on a value maintenance logic. The introduction of any sustainable material or process must first ensure seamless compatibility with existing quality standards, tactile aesthetics, and brand heritage [40]. Therefore, selection favors quality-equivalent substitutes, such as recycled wool or Orange Fiber, which can be integrated into the Made in Italy value narrative without altering established manufacturing process chains or consumer value perception. Sustainability is strategically incorporated here to reinforce, not challenge, the incumbent market positioning and value system.

Life-cycle Judgment Logic in Finland exhibits a front-loaded life-cycle judgment logic. The starting point for its material selection is a profound ecological valuation and scientific innovation, aiming for renewability, low environmental burden, and circular potential at the source [41]. Forest-based fibre innovations like Spinnova are paradigmatic examples. However, its relatively weak domestic textile manufacturing ecosystem creates an industrialisation bottleneck, resulting in a strong innovation, weak manufacturing disconnect. Thus, Finland's sustainability narrative strongly emphasizes full life-cycle transparency and ecological superiority based on scientific data; its material selection logic is fundamentally driven by ecological rationality.

4.2. The Place-Based Systemic Framework

In-depth analysis of the above differences reveals that each region's distinctive material selection logic is not accidental but an emergent product of its specific place-based system configuration. This study accordingly constructs an integrative Place-based Systemic Framework (see Figure 1) to explain the generative mechanisms of these logics. The framework comprises six interrelated core dimensions: Resource Ecology, Craft-Technology Pathway, Industrial Structure, Cultural Values, Design Decision Logic, and Sustainability Orientation. Together, these dimensions form a dynamic situational force field that shapes the judgment prism of designers and industrial decision-makers.
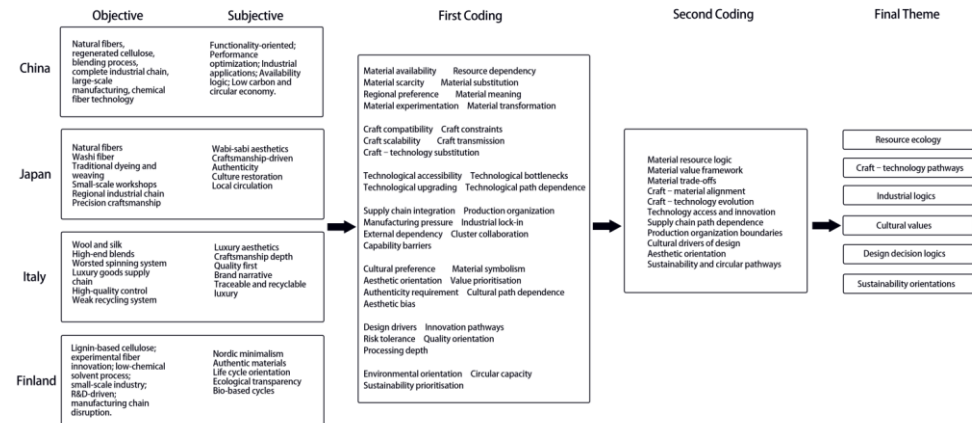
Figure 1. The Place-based Systemic Framework for Sustainable Material Selection.

The analysis demonstrates that regional differences essentially stem from variations in the weighting, prioritization, and interaction of these six dimensions:

When Resources and Industry dominate like China, the system fosters a Trade-off Decision Logic, seeking optimal solutions under constraints. When Craft and Culture are central as Japan, the system reinforces an Authenticity Logic, emphasizing continuity of meaning and transmission of skill. When Industry and Culture are tightly coupled within a high-end market like Italy, the system derives a Value Maintenance Logic, where all changes are preconditioned on preserving the existing value system. When Resources and Sustainability Orientation are the primary drivers as Finland, the system gives rise to a Life-cycle Judgment Logic, where ecological rationality becomes the starting point for design.

This framework transforms sustainable material selection from a seemingly subjective preference into a contextualized judgment process amenable to systematic analysis and understanding.

4.3. An Exploratory Model for Cross-Regional Sustainable Material Collaboration

Building on the Place-based Systemic Framework, this study further proposes an exploratory cross-regional collaboration suitability model (see Table 2). This model translates the six framework dimensions into assessment axes to analyze the Complementarity (C), Compatibility (CP), and Conflict Risk (CR) between any two regions for collaborative purposes.

Table 2. Cross-Regional Collaboration Suitability Matrix for Sustainable Material Design.

Mechanism (Dimension)	China × Japan	China × Finland	China × Italy	Japan × Finland	Japan × Italy	Italy × Finland
Resource Ecology	C-M	C-H	C-L	C-L	C-L	CP-L
Craft-Technology Pathway	CR-H	C-M	CP-L	CR-H	CP-M	CP-L

Industrial Logic	CR-H	CR-H	CP-H	CP-M	CP-L	CR-M
Cultural Value	CR-H	CR-M	CP-L	CP-M	CR-H	CP-L
Design Decision Logic	CR-H	CR-M	CP-L	CR-M	CP-M	CR-M
Sustainability Orientation	CP-L	CP-H	CP-L	CP-M	CP-M	CP-H

Note: C = Complementarity, CP = Compatibility, CR = Conflict Risk; H = High, M = Moderate, L = Low.

This model reveals different patterns of collaborative potential.

1) High-Complementarity Driven. Exemplified by the China-Finland pair. They show high complementarity in Resource Ecology and Sustainability Orientation. Finland's cutting-edge material innovation urgently requires China's mass-manufacturing and market-transformation capabilities for industrial-scale deployment, while China can enhance the depth and green credibility of its transition by incorporating Finland's eco-advanced materials and assessment frameworks. This represents a classic innovation-industrialisation complementarity.

2) High-Conflict-Risk Alert. Exemplified by China-Japan and Japan-Italy pairs. The former shows high conflict risk across almost all dimensions like industrial logic and cultural values, while the latter shows significant conflict in cultural values. This suggests that deep integration at the production level or in brand culture may be highly difficult and costly. Collaboration should focus more on knowledge exchange, inspiration, or cautious linkage of specific value-chain segments.

3) High-Compatibility Facilitated. Exemplified by the high compatibility in Industrial Structure between China and Italy. Both possess complex, mature industrial systems. Although their target markets differ, they share a common language in supply chain management, quality control, etc. This provides a facilitative base for cooperation in specific technical or managerial areas like premium recycled material development or lean production.

The core insight from this model is that effective cross-regional collaboration should not aim to eliminate differences or enforce uniform standards. Instead, it should be based on a deep understanding of the underlying logics of each party, actively seeking and designing synergy across differences. The success of collaboration depends on the ability to transform the conflict risks arising from systemic differences into complementary advantages capable of creating new value.

5. Conclusion and Implications

5.1. Key Findings

Through a systematic comparison of four regions consist of China, Japan, Italy, and Finland, this study reveals a central argument: sustainable textile material selection is not an engineering problem seeking a universal technical optimum, but a contextualized

design judgment process deeply embedded within place-based socio-technical systems. Specifically:

1) Divergent Selection Logics. The four regions exhibit dominant material selection logics. Trade-off Decision-Making in China, Authenticity Logic in Japan, Value Maintenance Logic in Italy, and Life-cycle Judgment Logic in Finland. These logics are not arbitrary preferences but coherent responses to their local conditions.

2) Systemic Generative Mechanisms. These differences are rooted in distinct configurations and weightings across six dimensions: Resource Ecology, Craft-Technology Pathway, Industrial Structure, Cultural Values, Design Decision Logic, and Sustainability Orientation. The Place-based Systemic Framework constructed in this study clearly delineates this generative relationship from system configuration to judgment logic.

3) Collaborative Potential and Pathways. Analysis based on this framework indicates that the key to cross-regional collaboration lies not in standardization or one-way learning, but in identifying and leveraging complementarities between systemic logics. For instance, significant synergistic potential exists between Finland's ecological innovation and China's industrialization capability, or between Italy's value narrative and Japan's craft depth, albeit alongside conflict risks that require management.

5.2. Theoretical Contributions

The theoretical contributions of this study are threefold: First, it advances the understanding of the geography of sustainability transitions. Moving beyond regional studies often based on technology diffusion or policy comparison, it proposes an analytical framework centered on place-based system configuration and contextualized judgment logic. This framework provides a robust mid-range theoretical explanation for why diversified pathways persistently exist in global sustainable practice.

Second, it integrates design research into the systemic analysis of sustainable material selection. By synthesizing craft, culture, design strategy, and industrial logic, the study demonstrates that material selection is a composite socio-techno-cultural practice, thereby bridging perspectives from design studies, industrial economics, and the sociology of technology that are often separate. Third, the proposed exploratory collaboration model offers a new systemic complementarity perspective for cross-regional collaboration theory, moving beyond a capability gap view. It emphasizes that collaborative design should begin with understanding and respecting the internal logics of all parties, aiming to create synergistic effects across differences. This provides a novel conceptual tool for research on sustainability transition collaboration in a globalized context.

5.3. Practical and Policy Implications

The findings carry direct implications for industry practitioners, designers, and policymakers.

For Industry and Designers, when engaging in transnational projects or introducing new materials, a place-based system compatibility analysis should be conducted first. Understanding the underlying logic of the target market can prevent misfit. Collaboration should seek logically complementary partners, for instance, pairing material innovators with scale manufacturers, or linking craft custodians with brand storytellers to co-develop new products or markets.

For Policymakers, one-size-fits-all industrial policies or sustainability standards may have limited efficacy. Policy should focus more on enabling place-based systems to develop distinctive transition pathways built on their own strengths. Concurrently, platforms can be established to facilitate cross-regional dialogue and matching, helping different logical systems identify complementary opportunities while designing mechanisms to mitigate potential cultural and industrial logic clashes in cooperation.

For Educators, sustainable design education should strengthen training in systems thinking and contextual analysis. Future designers need to become cultural-technical mediators capable of translating and bridging across different place-based logics, rather than merely being technicians versed in universal design tools or material databases.

5.4. Limitations and Future Research Directions

This study has several limitations, which also point to future research directions. First, the breadth of cases is limited. All four cases are from Eurasia, not encompassing regions with different colonial histories, knowledge systems, and development stages, such as Africa, South Asia, or Latin America. Future research incorporating more diverse cases will be crucial for testing and refining the general applicability of this framework. Secondly, the study relies primarily on static analysis of secondary data, capturing the relatively stable systemic features of a specific period. However, place-based systems are dynamic, susceptible to influences from technological breakthroughs, major policies, global market shocks, or social movements. Longitudinal studies or process research tracking how critical events reshape local material logics would significantly enhance the framework's dynamic explanatory power. Finally, the collaboration model presented is exploratory and qualitatively assessed. Future research could validate and refine this model through in-depth case studies or develop more fine-grained indicator systems to make the assessment of complementarity and conflict risk more operational.

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