A Decentralized Supply Chain Architecture for Fragmented Artisan Economies: Mitigating Intermediary Exploitation through Digital Disintermediation

Dr Sandeep Sachan

Associate Professor

National Institute of Fashion Technology

Varanasi, Uttar Pradesh, India

sandeep.sachan@nift.ac.in

Abstract: The Indian handicraft sector is a highly decentralized, labor-intensive industry that supports over 7 million artisans. However, the economic sustainability of this creative economy is severely hindered by highly fragmented supply chains, a lack of direct market access, and significant profit extraction by intermediaries. This paper proposes a conceptual digital supply chain architecture tailored for decentralized artisan clusters. Moving beyond traditional e-commerce models, the proposed system integrates an algorithmic inventory layer, a localized mobile interface for low-literacy populations, and a transparent transaction ledger to establish a direct Peer-to-Peer (P2P) pipeline between rural producers and global consumer markets. We analyze the system's capacity to streamline forward and backward economic linkages—connecting raw material suppliers to global retail networks. The framework demonstrates how targeted digital infrastructure can mitigate structural market barriers, ensure equitable revenue distribution, and foster long-term socio-economic viability for traditional craft ecosystems.

Keywords: Supply Chain Architecture, Decentralized Systems, Smart Contracts, Digital Disintermediation, Provenance Tracking, Rural Techno-Economics

1. INTRODUCTION

The vast tradition of handicrafts in India is a reflection of cultural variety, historical legacy, and indigenous knowledge systems. Handicrafts such as Varanasi and Channapatna woodwork lacquer toys, Kashmir carpets, Kutch needlework, and Madhubani paintings are vital to India’s cultural identity and soft power internationally. Operating as one of the largest decentralized and labor-demanding sectors of the country, the craft sector occupies a unique position in the Indian economy since it provides jobs at a relatively low level of capital investment while supporting sustainable livelihoods.
The Ministry of Textiles and NITI Aayog acknowledge the handicraft sector as an important component for inclusive growth, rural poverty reduction, and non-farm rural employment. It is an essential driver of economic involvement and empowerment for rural households, indigenous tribes, and women, who represent a large share of the labor force involved in weaving, stitching, and home-based craft production.

Despite its vital role, the sector is experiencing significant disruptions due to globalization, competition from mass-produced machine commodities, severe barriers to market entry, and a lack of technical usage among artisans. Young people are increasingly abandoning the craft traditions due to inadequate compensation and a lack of defined career paths. This paper addresses these vulnerabilities by designing a decentralized supply chain system architecture that leverages information technology to remove exploitative intermediaries, optimize raw material sourcing, and preserve authentic cultural assets via automated provenance tracking.

2. PROBLEM FORMULATION & SYSTEM REQUIREMENTS

To build a computationally viable supply chain framework, the empirical challenges of the artisanal sector must be translated into formal technical problem statements:

1. **The Intermediary Skimming Problem (Asymmetric Information):** Artisans lack direct contact with end markets and rely heavily on intermediaries. This creates an information asymmetry where dealers extract disproportionate profits compared to the manufacturers.
   • *System Requirement:* A Peer-to-Peer (P2P) transaction layer that bypasses centralized middlemen and enforces transparent revenue sharing.

2. **The Authenticity & Counterfeit Problem (Market Competition):** Mass-produced mechanical goods mimic traditional crafts at a lower cost, diminishing the demand for authentic handcrafted items.
   • *System Requirement:* A cryptographic validation system linked to Geographical Indication (GI) registries to verify product authenticity.

3. **The Digital Divide (Low-Tech Accessibility):** Rural artisans are frequently restricted by low digital literacy and limited access to modern e-commerce platforms.
   • *System Requirement:* A highly localized, low-bandwidth, and multimodal user interface (UI) layer.

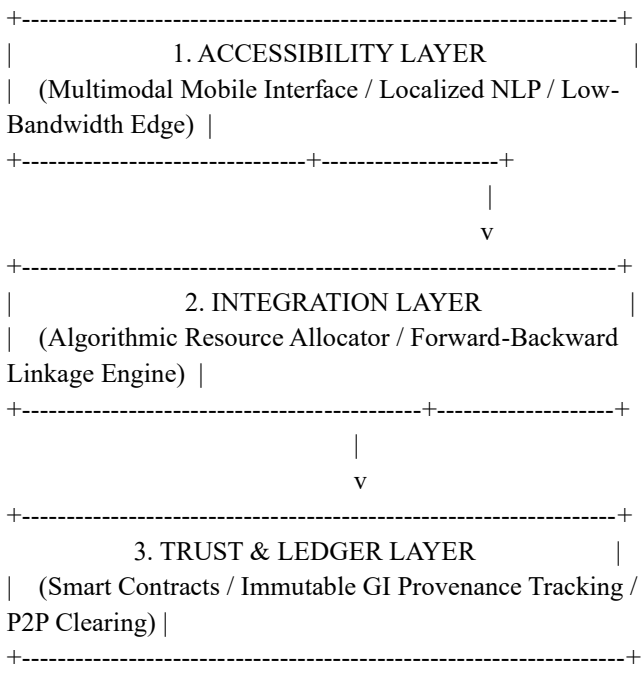
4. **Supply Chain Fragmentation:** Artisan clusters suffer from unstable pricing, poor tracking of backward linkages (raw materials), and disconnected forward linkages (logistics and global markets).
   • *System Requirement:* An automated, data-driven orchestration engine to manage resource allocation and inventory matching.

3.METHODOLOGY

This study employs a System Requirements Engineering approach paired with a Techno-Economic Analysis. The design methodology translates secondary empirical data and operational reports from the Ministry of Textiles (2024), NITI Aayog (2021), UNESCO (2022), and the Export Promotion Council for Handicrafts (EPCH, 2024) into functional technical specifications.
The structural vulnerabilities of artisan clusters—ranging from raw material shortages to lopsided profit distributions—are mathematically and architecturally modeled. The paper develops a conceptual three-tier digital architecture designed to optimize decentralized economies without requiring heavy local capital investment.

4. PROPOSED SYSTEM ARCHITECTURE

The proposed digital supply chain framework is structured into three interdependent layers, isolating user interaction from complex data coordination and ledger execution.



4.1. Accessibility Layer (Frontend Tier)

To overcome the low-tech limitations of rural craft clusters, the edge interface is built as a Mobile-First Progressive Web Application (PWA).

- **Multimodal Input Processing:** The layer integrates lightweight, Natural Language Processing (NLP) voice-to-text models capable of processing regional dialects. Artisans can log items locally by speaking descriptive details (e.g., material type, craft technique) rather than navigating complex text interfaces.

- **Low-Bandwidth Optimization:** The edge application utilizes local offline storage (IndexedDB) to cache transactions, inventory additions, and raw material requests. Data synchronization with the central integration layer occurs via opportunistic scheduling only when a stable cellular network connection is detected, preventing data loss in remote areas.

4.2. Integration & Orchestration Layer (Middleware Tier)

This layer acts as the computational engine that coordinates the backward and forward linkages of the artisan cluster economy.

Backward Linkage Optimization (Raw Material Aggregation)

Artisan clusters frequently suffer from volatile raw material pricing and quality constraints. The middleware executes a bulk-demand aggregation algorithm. Let $A = \{a_1, a_2, \dots, a_n\}$ represent a localized cluster of artisans, and r_{i} represent the quantity of raw material demanded by artisan a_i. The system computes total demand:

$$\text{Total Demand } (R) = \sum_{i=1}^{n} r_i$$

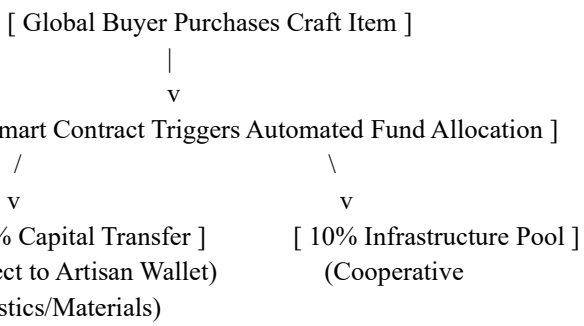
When R cross-references a predefined optimal purchasing threshold, the system auto-generates a bulk purchase requisition directly to verified raw material suppliers. This bypasses local speculative traders, drives down procurement costs, and stabilizes supply chains.

Forward Linkage Optimization (Demand Matching Engine)

The integration layer maps real-time international consumer demand data from global markets (e.g., USA, UK, Germany) and tourism networks against available artisan inventory. By applying a predictive matching model based on historic sales data—such as the recorded 2.5% export growth trajectories—the engine alerts artisan cooperatives on which specific craft categories (e.g., carpets, embroidered fabrics, or woodwork) have high global purchasing velocity.

4.3. Trust & Ledger Layer (Backend Tier)

The backend layer replaces standard centralized databases with a distributed ledger framework to ensure transparency, enforce cryptographic authenticity, and achieve digital disintermediation.



Smart Contract Revenue Execution

To prevent intermediaries from acquiring disproportionate profits, all financial interactions are governed by immutable smart contracts. When a global consumer buys a piece of handicraft, the transaction protocol triggers an automated fund execution path. The buyer's payment is split algorithmically: the vast majority (e.g., 90%) is systematically transferred directly to the verified artisan's digital wallet, while the remaining balance (e.g., 10%) is allocated to a decentralized cooperative pool for logistics and raw material management. This layout ensures transparent, intermediary-free revenue generation.

Cryptographic GI & Provenance Tracking

To insulate the craft sector from cheap, machine-manufactured duplicates, the architecture pairs physical goods with an unalterable digital identity. When an artisan registers an authentic craft belonging to a recognized Geographical Indication (such as Banarasi Brocade or Channapatna Toys), a cryptographic token is minted on the ledger.

This token maps metadata including the artisan's identity, geographic coordinates of production, and raw material origin. A secure, tamper-evident QR code or near-field communication (NFC) tag is affixed to the physical craft. Global consumers or tourism participants scan the tag to mathematically verify the product's cultural authenticity, protecting the craft's premium market value.

5. System Evaluation & Socio-Economic Impact Analysis

Implementing a decentralized supply chain architecture directly alters the socio-economic indicators of the artisan ecosystem:

Challenge Vector	Traditional Supply Chain Status	Proposed Architectural Intervention	Expected Techno-Economic Outcome
Revenue Distribution	Middlemen extract high margins; artisans face low returns.	Smart Contract Direct Ledger Settlement.	Elimination of middleman fees; higher local income.
Authentication	Counterfeiting by machine-made alternatives.	Cryptographic GI Provenance Tokenization.	Shielded market differentiation for genuine crafts.
Material Sourcing	Fragmented, high-cost,	Algorithmic Backward	Economies of scale; minimized

	irregular quality.	Demand Aggregation.	production overheads.
Market Integration	Isolation from global e-commerce and tourism streams.	Demand Optimization Middleware Tier.	Data-driven export positioning and target marketing.

By deploying this decentralized model, the reliance on manual linkages is mitigated. The architecture establishes a direct feedback loop where international market demands are immediately transparent to rural producers. Providing sustainable, predictable revenue models and integrating modern computing paradigms addresses the core reason younger generations turn away from the sector, preserving India's rich cultural heritage through software-driven viability.

6. CONCLUSION

The Indian handicraft industry represents an environmentally sustainable, labor-intensive asset capable of driving decentralized economic growth, rural development, and international soft power. However, traditional structural mechanisms leave the primary producers vulnerable to market displacement and financial exploitation. This paper has detailed a conceptual decentralized supply chain architecture engineered specifically for low-resource environments. By organizing the platform into an accessible edge layer, an algorithmic matching middleware tier, and a smart contract transaction layer, the framework addresses the systemic problems of intermediary exploitation, counterfeit product competition, and supply chain opacity. Transitioning the craft ecosystem onto a transparent, data-driven framework safeguards indigenous knowledge assets and creates an equitable economic foundation for future generations of artisans.

Conflict of Interest: The corresponding author, on behalf of second author, confirms that there are no conflicts of interest to disclose.

References

[1] Das, D. (2019). Indian handicraft industry: Problems and prospects. *International Journal of Management Studies*, 6(2), 45–54.

[2] Export Promotion Council for Handicrafts. (2024). *Handicrafts export statistics report*. New Delhi, India: Author.

[3] Jaitly, J. (2012). *Atlas of Indian handicrafts*. New Delhi, India: Niyogi Books.

[4] Ministry of Textiles. (2024). *Annual report 2023–2024*. Government of India.

[5] NITI Aayog. (2021). *Traditional crafts for rural livelihoods*. Government of India.

[6] Strategic Supply Chains in the New World Order: Rare Earths, Realignment, and Resilience. (2025). *Frontiers in Social Sciences Research*, *1*(4), 26-32. https://doi.org/10.24113/4yh9yp73

[7] Richards, G. (2018). Cultural tourism: A review of recent research and trends. *Journal of Hospitality and Tourism Management*, 36, 12–21. https://doi.org/10.1016/j.jhtm.2018.03.005

[8] Singh, A., & Sharma, R. (2020). Contribution of handicraft sector in India. *Journal of Rural Development*, 39(3), 411–428.

[9] UNESCO. (2022). *International trade trends in creative industries: Creative economy perspective*. Paris, France: UNESCO.