

# Value Chain Analysis of Forestry Logistics Enterprises in China: Strategic Implications for Operational Resilience, Digital Integration, and Sustainable Value Creation

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## ABSTRACT

This study examines China's micro- and small-sized forestry logistics enterprises (MSFLEs), which constitute nearly 99% of national logistics firms yet remain underexplored in scholarly research. Drawing on Porter's value chain framework, extended by global value chain and service-dominant logic perspectives, we investigate misalignments between strategic importance and operational performance. Employing a mixed-methods design, we synthesized literature to identify research gaps and conducted an Importance-Performance Analysis (IPA) survey of 79 MSFLEs in Fujian Province. Results highlight critical deficiencies in supplier delivery reliability, distribution cost control, cold-chain management, and customer demand sensing. These gaps stem from systemic constraints—fragmented supplier networks, legacy cost structures, and limited technological or market intelligence—rather than operational inefficiency. IPA findings suggest that MSFLEs function effectively as “execution agents” but lack capacity for strategic value co-creation, particularly in upstream coordination and data-driven decision-making. To address these challenges, we propose a three-tiered pathway: strengthening supplier collaboration through technology, adopting low-cost digital tools selectively, and specializing in niche services such as sustainable timber traceability.

**Keywords:** logistics value chain; micro-enterprises; forestry supply chain; importanceperformance analysis (IPA); digital transformation; China; sustainable logistics.

## Introduction

Logistics is the circulatory system of modern economies, with its efficiency directly determining national competitiveness and sustainability [1]. Within China's rapidly evolving logistics landscape, micro- and small-sized enterprises (MSMEs) constitute the foundational layer—accounting for approximately 99% of all logistics firms and serving as indispensable “capillaries” in regional freight networks [1]. Yet, this segment remains critically understudied in international literature, particularly when specialized in resource-intensive sectors like forestry. Forestry logistics enterprises (FLEs) face unique complexities: handling bulky, perishable, and often regulated commodities (e.g., timber, bamboo, non-timber forest products); operating across vast, topographically challenging rural landscapes; and navigating stringent environmental compliance regimes (e.g., China's “Dual Carbon” goals). Their value chains are thus not merely scaled-down versions of large carriers but distinct ecosystems shaped by ecological constraints, policy mandates, and localized market dynamics. While prior research has established the theoretical relevance of value chain analysis for logistics [11], [5], most empirical applications focus on large, multinational third-party logistics providers (3PLs) or manufacturing-centric supply chains [3].

Studies on Chinese MSMEs often conflate heterogeneous sectors (e.g., e-commerce fulfillment, urban courier, industrial logistics) or rely on macro-level statistical data, obscuring the granular operational realities of niche players like FLEs [4], [12]. This gap is consequential: without precise diagnostics of where value is created, captured, and lost within their specific context, MSFLEs risk being trapped in low-value, pricecompetitive niches, unable to leverage their inherent agility for strategic advantage. This study therefore addresses a dual research void: (1) the lack of sector-specific value chain analysis for China's forestry logistics sector, and (2) the absence of empirically validated, actionable frameworks for MSFLEs to navigate digitalization and sustainability imperatives. Drawing on primary data from Fujian Province—a national leader in forestry output and ecological conservation—we apply Importance-Performance Analysis (IPA) to diagnose critical misalignments and propose a contextually grounded strategy for value chain upgrading. Our contribution lies in translating abstract value chain theory into a practical, evidence-based roadmap for resilience and growth in one of the world's most dynamic yet fragmented logistics markets.

## Theoretical Foundations and Literature Review From Generic Value Chains to Forestry-Specific Configurations

Porter's seminal value chain model provides the foundational architecture, distinguishing primary activities (inbound logistics, operations, outbound logistics, marketing & sales, service) from support activities (firm infrastructure, human resource management, technology development, procurement) [11]. For MSFLEs, this framework must be contextualized. Inbound logistics for FLEs is not merely procurement but involves complex coordination with scattered, often informal, forest harvesters and cooperatives—a process highly vulnerable to seasonal fluctuations and regulatory audits [14]. Outbound logistics extends beyond delivery to include compliance documentation for cross-provincial timber transport, a critical yet frequently overlooked value-adding activity (Chen & Li, 2023).

The global value chain (GVC) literature further enriches this view. Gereffi and Fernandez-Stark's "governance" lens highlights how power asymmetries between large downstream processors (e.g., furniture manufacturers) and upstream MSFLEs constrain value capture [2], [3]. Similarly, the work on GVC participation shows that MSFLEs are typically embedded at the lowest tiers ("input suppliers"), capturing minimal value-added due to limited bargaining power and technical capacity [6]. This positions them not as autonomous value creators but as dependent nodes whose upgrading potential hinges on external enablers—policy support, technology access, and collaborative platforms.

### The Digital and Sustainable Imperatives

Contemporary value creation in logistics is increasingly defined by two intertwined forces: digital integration and green transition. The literature consistently links digital technologies—such as IoT sensors for real-time cargo monitoring, AI-powered route optimization, and blockchain for provenance tracking—to significant gains in cost efficiency, service reliability, and transparency [4], [13]. However, for MSFLEs, the barrier is not technological feasibility but affordability and absorptive capacity. As the "digital divide" for Chinese MSMEs is less about access and more about the human capital and organizational routines needed to deploy and benefit from these tools [13].

Simultaneously, sustainability is no longer a peripheral concern but a core value driver. China's "Dual Carbon" goals (carbon peak by 2030 and carbon neutrality by 2060) policy framework imposes direct operational requirements on FLEs, from mandating electric or hybrid vehicles in urban zones to requiring carbon footprint reporting for timber shipments [14]. The such regulatory pressures can act as catalysts for upgrading, forcing firms to move up the value chain—from simple transport to integrated, low-carbon logistics solutions [2]. Thus, the value chain of a modern MSFLE must be conceptualized as a dual-axis system: one axis measuring traditional efficiency (cost, speed, accuracy), and the other measuring sustainability performance (emissions, energy use, circularity).

### Synthesis and Research Gap

The literature converges on several key insights: (1) MSFLEs operate in a structurally disadvantaged position within GVCs; (2) their value creation is constrained by tangible (infrastructure, capital) and intangible (skills, data, governance) bottlenecks; and (3) digital and green transitions represent both existential threats and unprecedented

opportunities for strategic differentiation. However, a critical gap remains: there is a paucity of empirical, granular studies that map the specific importance–performance gaps within the forestry logistics value chain and translate those findings into a coherent, implementable strategy. This study bridges that gap.

### Methodology Research Design and Sampling

A cross-sectional survey design was employed, targeting MSFLEs registered in Fujian Province, China. Fujian was selected due to its status as a national leader in forestry production (contributing >10% of China's total timber output) and its advanced provincial policies on green logistics and digital agriculture (Fujian Provincial Government, 2023). Using a snowball sampling technique to overcome the challenge of identifying and accessing this dispersed population, 100 questionnaires were distributed to owner-managers between January and March 2025. A total of 87 responses were received, of which 79 were complete and valid, yielding a response rate of 79%. The sample demographics (Table 1) confirm its representativeness: the majority of respondents are male (91.1%), aged 40–59 years (56.9%), with a high school education (24.1%), and possess 11+ years of industry experience (46.8%). This profile aligns closely with national statistics on Chinese MSME owner-managers [9].

Table 1: Sample Demographics (N = 79)

| Variable   | Category               | Frequency | Percentage (%) |
|------------|------------------------|-----------|----------------|
| Gender     | Male                   | 72        | 91.1           |
|            | Female                 | 7         | 8.9            |
| Age        | 40–59 years            | 45        | 56.9           |
|            | 30–39 years            | 16        | 20.3           |
|            | 60+ years              | 11        | 13.9           |
|            | 20–29 years            | 7         | 8.9            |
| Education  | High School/Vocational | 19        | 24.1           |
|            | University             | 16        | 20.3           |
|            | Junior High School     | 16        | 20.3           |
| Experience | 11–15 years            | 16        | 20.3           |
|            | 26+ years              | 14        | 17.7           |
|            | 5 years or less        | 21        | 26.6           |

### Instrument and Data Collection

The survey instrument was adapted from established scales in logistics value chain research [1, Mentzer et al., 2001]. It comprised 56 items organized into nine constructs: Inbound Logistics, Transportation Operations, Outbound Logistics, Marketing & Sales, Customer Service, Infrastructure, Human Resource Management, Technology Development, and Procurement. Each item was measured on a 5-point Likert scale for both Importance ("How important is this activity for your firm's competitive advantage?") and Performance ("How well does your firm currently perform this activity?"). Internal consistency was confirmed with Cronbach's alpha = 0.805, indicating strong reliability [10].

### Analytical Approach: Importance-Performance Analysis (IPA)

IPA is a robust, managerially intuitive tool for prioritizing strategic initiatives [7]. It plots each activity on a two-dimensional matrix: the X-axis represents the mean importance score, and the Y-axis represents the mean performance score. The matrix is divided into four quadrants by the overall mean scores for importance (3.89) and performance (3.07): Quadrant I (Keep Up the Good Work): High importance, high performance. These are core competencies to maintain.

Quadrant II (Too Much of a Good Thing): Low importance, high performance. Resources may be over-allocated here.  
 Quadrant III (Low Priority): Low importance, low performance. These are low-yield activities.  
 Quadrant IV (Concentrate Here): High importance, low performance. These are critical areas demanding urgent investment and improvement.  
 This method directly addresses the study's purpose: to identify not just what is important, but where the most critical operational deficits lie relative to strategic priorities.

**Findings Critical Importance-Performance Gaps (Quadrant IV)**

The IPA analysis revealed nine activities falling squarely in Quadrant IV—the "concentrate here" zone—representing the most acute strategic vulnerabilities (Table 2). These activities share a common theme: they are relational, informational, and systemic, rather than purely physical or transactional.

Table 2: Key Quadrant IV Activities (High Importance, Low Performance)

| Activity  | Mean Importance | Mean Performance | Gap   |
|---|-----------------|------------------|-------|
| Supplier delivery timeliness                            | 4.51            | 2.81             | -1.70 |
| Distribution cost control mechanism                     | 4.47            | 2.92             | -1.55 |
| Delivery timeliness and on-time rate                    | 4.25            | 2.75             | -1.50 |
| Smart warehouse (automated sorting/picking) application | 4.24            | 2.97             | -1.27 |
| External supplier evaluation and management mechanism   | 3.92            | 2.76             | -1.16 |
| Automated reporting and KPI management technology       | 4.16            | 3.06             | -1.10 |
| Customer demand investigation mechanism                 | 4.03            | 3.01             | -1.02 |
| Personnel training                                      | 3.89            | 2.94             | -0.95 |
| Order inquiry and logistics tracking functionality      | 3.97            | 3.04             | -0.93 |

The largest gap (-1.70) is in supplier delivery timeliness. This finding is profound: it indicates that MSFLEs perceive reliable upstream coordination as their single most critical success factor, yet they are failing spectacularly in this domain. This is not a failure of internal logistics but a symptom of a fragmented, informal, and poorly governed upstream supply base—a classic GVC governance challenge [2]. Similarly, the severe deficit in distribution cost control (-1.55) points to a reliance on manual, reactive cost management rather than predictive analytics and dynamic pricing models, leaving firms exposed to volatile fuel prices and labor costs.

Table 3: Summary of Value Chain Constructs (N = 79)

| Construct                 | No. of Items | Mean Importance | Mean Performance | Gap   |
|---------------------------|--------------|-----------------|------------------|-------|
| Inbound Logistics         | 4            | 4.20            | 3.11             | -1.09 |
| Transportation Operations | 5            | 4.30            | 3.10             | -1.20 |
| Outbound Logistics        | 4            | 3.98            | 3.19             | -0.79 |
| Marketing & Sales         | 6            | 3.78            | 3.00             | -0.78 |
| Customer Service          | 4            | 4.03            | 3.16             | -0.87 |
| Infrastructure            | 12           | 3.76            | 3.23             | -0.53 |
| Human Resource Management | 12           | 3.66            | 2.95             | -0.71 |
| Technology Development    | 4            | 4.09            | 2.96             | -1.13 |
| Procurement               | 5            | 3.86            | 2.94             | -0.92 |

**Strengths and Over-Investments (Quadrants I & II)**

In contrast, Quadrant I (high importance/high performance) contains 20 activities, predominantly related to tangible assets and basic execution. These include "transport vehicle equipment (including maintenance and renewal) completeness" (Importance: 3.96; Performance: 3.35), "geographical location impact on logistics efficiency" (3.96; 3.29), and "logistics auxiliary equipment and tools" (3.97; 3.33). This confirms that MSFLEs have successfully built competence in the physical, visible aspects of their business—their "hardware." Notably, "cold-chain temperature management" also falls in Quadrant I (4.42; 3.13), suggesting that MSFLEs have developed reasonable capabilities in this specialized area, likely driven by market demand for temperature-sensitive forest products.

However, Quadrant II (low importance/high performance) reveals potential over-investment in areas like "administrative workflow automation" (Importance: 3.34; Performance: 3.11) and "compliance with regulatory transport permits and safety certification" (3.41; 3.11). While necessary, these are table-stakes compliance activities, not sources of competitive differentiation.

Resources allocated here could be better deployed toward Quadrant IV priorities.

**The Human Capital Paradox**

A striking finding emerges from the Human Resource Management construct. While "personnel training" is a critical Quadrant IV priority (Importance: 3.89; Performance: 2.94; Gap: -0.95), the satisfaction with "personnel promotion" is relatively moderate (Importance: 3.39; Performance: 3.06). This suggests a paradox: MSFLEs recognize the need for upskilling but lack the structured career pathways and incentive systems to retain trained talent. This reflects the prevalent familyrun, informal management structure noted by Tian (2012), where formal HR practices are underdeveloped, creating a vicious cycle of skill shortage and high turnover.

Table 4: Complete IPA Quadrant Distribution (N = 56 Items)

| Quadrant     | Description   | No. of Items |
|--------------|---|--------------|
| Quadrant I   | Keep Up the Good Work (High Importance, High Performance)   | 20           |
| Quadrant II  | Too Much of a Good Thing (Low Importance, High Performance) | 7            |
| Quadrant III | Low Priority (Low Importance, Low Performance)              | 20           |
| Quadrant IV  | Concentrate Here (High Importance, Low Performance)         | 9            |

**Discussion and Strategic Framework**

The findings paint a clear picture: MSFLEs are operationally competent in executing discrete tasks but strategically weak in managing relationships, leveraging information, and integrating systems. Their value chain is characterized by islands of excellence surrounded by seas of vulnerability. To move beyond survival to sustainable growth, a targeted, multi-tiered strategy is required.

**The Three-Tiered Strategic Framework**

We propose a framework that moves from foundational stability to strategic differentiation

### Tier 1: Stabilize the Foundation (Address Quadrant IV Gaps 1 & 9)

The root cause of the supplier timeliness gap is not poor logistics but poor supply chain governance. Therefore, the first strategic imperative is to move from ad-hoc, transactional relationships with upstream suppliers to formalized, technology-mediated collaboration. This does not require building a proprietary platform. Instead, MSFLEs should collectively adopt and co-fund a shared, cloud-based supplier portal (e.g., a simplified version of Alibaba's 1688.com for forestry). This portal would standardize order placement, provide real-time harvest progress updates, and facilitate electronic payment, thereby reducing uncertainty and improving planning accuracy for all parties. This aligns with the GVC literature's emphasis on "governance upgrading" as a prerequisite for functional upgrading [2].

### Tier 2: Digitize Selectively (Address Quadrant IV Gaps 2, 5, 7, 8)

Rather than pursuing expensive, enterprise-wide digital transformation, MSFLEs should adopt a "modular digitalization" strategy. Prioritize low-cost, high-impact tools: GPS Fleet Management Systems: To optimize routes, reduce fuel consumption, and provide real-time ETAs to customers (addressing cost control and delivery timeliness). Automated KPI Dashboards: To replace manual reporting, providing instant visibility into key metrics like on-time delivery rate and cost per ton-kilometer (addressing KPI management). Blockchain-Based Traceability Modules: To generate verifiable, tamper-proof records of timber origin and transport conditions, meeting growing demand for sustainable sourcing from downstream buyers (addressing customer demand and service).

This approach leverages the "lightweight digital tools" trend identified, making digital benefits accessible without overwhelming organizational capacity [13].

### Tier 3: Specialize Strategically (Leverage Quadrant I Strengths)

MSFLEs' greatest untapped asset is their deep, localized knowledge of the forestry ecosystem. They should leverage their strengths in "geographical location" and "transport convenience" to develop hyper-specialized, high-margin services.

Examples include: "Just-in-Time Millyard Logistics": Offering precision scheduling and inventory management for sawmills, reducing their costly raw material stockpiles.

"Certified Sustainable Timber Logistics": Bundling transport with verification services for FSC or PEFC certification, commanding premium rates from eco-conscious buyers.

"Bamboo Supply Chain Integration": Developing end-to-end logistics for the fast-growing bamboo sector, from harvest to processing plant, a niche where large 3PLs lack expertise.

This strategy embodies the "specialized, refined, distinctive, and innovative" (Zhuan Jing Te Xin) philosophy promoted by Chinese industrial policy, moving MSFLEs from price takers to value cocreators [8].

### Policy Implications

This framework has clear implications for policymakers. Support should shift from generic subsidies for hardware (e.g., vehicle purchases) to targeted programs that address Quadrant IV gaps:

Co-funding for Collaborative Platforms: Subsidies for MSFLE consortia to develop and adopt shared digital infrastructure.

"Digital Literacy" Training Grants: Not just for software use, but for data-driven decision-making and supplier relationship management.

Green Certification Support: Streamlining the process and subsidizing the costs for MSFLEs to obtain certifications that unlock premium markets.

### Conclusion

This study provides the first empirically grounded, sector-specific diagnosis of the value chain for China's forestry logistics enterprises. By applying IPA to primary data from Fujian Province, we have moved beyond theoretical abstraction to identify the precise, actionable levers for strategic intervention. The central finding—that MSFLEs' most critical weaknesses lie in relational, informational, and systemic capabilities, not physical execution—reframes the challenge of their development. Their path forward is not to become smaller versions of large 3PLs, but to leverage their unique position as agile, embedded actors within the forestry ecosystem to build new forms of value: trust-based collaboration, data-driven transparency, and sustainable specialization. This research contributes to the international logistics literature by demonstrating how value chain theory must be dynamically adapted to the institutional, technological, and ecological realities of emerging economies. Future research should explore the longitudinal impact of implementing the proposed three-tiered framework and investigate similar value chain configurations in other resource-based logistics sectors (e.g., agricultural, mining).

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