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ASSESSING THE FACTORS AFFECTING SUPPLY CHAIN PERFORMANCE IN THE HANDLOOM INDUSTRY IN THE CENTRAL PROVINCE OF SRI LANKA

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ABSTRACT

Supply chain performance (SCP) plays a critical role in improving efficiency and competitiveness; however, its application in traditional craft-based industries remains limited. In Sri Lanka's handloom sector, SCP concepts and performance metrics are poorly understood, and empirical evidence is scarce. This study addresses this gap by providing a structured assessment of SCP in the handloom industry, focusing on government-operated centres in the Central Province. Owing to the absence of systematically recorded operational data in the sector, this study adopts a perception-based approach using expert judgment. Qualitative interviews were conducted to map the supply chain and identify inefficiencies. The Analytic Hierarchy Process (AHP) was applied with nine experts to prioritise SCP-related factors. Additionally, 24 SCP measures were evaluated by 20 experts using a Likert-scale questionnaire to assess current performance levels. The results identify sourcing as the most influential determinant of SCP, followed by operational, transportation, and distribution, and market factors. Economic and customer satisfaction dimensions show satisfactory performance, whereas operational efficiency and flexibility remain weak. This study contributes academically by extending SCP frameworks to a traditional, data-constrained industry using a hybrid methodological approach. In practice, it offers policymakers actionable strategies to enhance efficiency while preserving the sector's cultural integrity.

Keywords: *Supply chain, supply chain performance, supply chain performance measures, supply chain efficiency, Sri Lankan handloom, AHP*

1. INTRODUCTION

Sri Lanka's handloom industry, one of the nation's oldest crafts, is deeply embedded in its cultural and historical fabric. Its roots extend over two millennia, with references in the *Mahavamsa* noting that when Prince Vijaya arrived in Sri Lanka around 543 BC, Kuweni was weaving on a loom [1]. Over the centuries, handloom weaving has evolved from household craftsmanship into an artisanal industry producing cotton and silk textiles that were once traded with India and China [2]. Today, it remains an important cottage-based enterprise, mainly driven by women, producing sarees, shawls, sarongs, household linen, upholstery, and other fabrics for both domestic and export markets [2]. According to the Export Development Board, eight provincial councils oversee 771 production centres and approximately 962 private producers, collectively employing nearly 15,000 people [3].

Despite its cultural value and social significance, the handloom industry continues to face persistent obstacles that restrict its competitiveness in the market. Most enterprises operate on a small scale and remain heavily dependent on imported raw materials, particularly yarn sourced from India and China [1]. Inadequate infrastructure, outdated equipment, and reliance on intermediaries for marketing have collectively limited access to more profitable markets and reduced income for weavers [4]. Efficiency is further hindered by coordination gaps across key stages, including production, dyeing, and distribution. Additionally, innovation has been hindered by restricted financial access and a lack of adequate training opportunities [5]. These structural weaknesses were further highlighted during the COVID-19 pandemic, when disruptions in transportation, labour shortages, and raw material shortages significantly impacted the sector's operations [6].

Similar handicraft sectors elsewhere show parallel weaknesses, poor market linkages, lack of working capital, and inefficient supply chain (SC) coordination [7], [8]. In Sri Lanka, these inefficiencies are reflected in economic outcomes: handloom exports contribute only approximately 1% to the country's apparel and textile export earnings, as shown in Figure 1, indicating serious underutilisation of production capacity. Media and policy analyses have identified the industry as one of "high potential but low performance" [9], constrained by weak SC integration, policy fragmentation, and limited human capital development [10].

i. To map the current SC structure
ii. To identify existing inefficiencies and issues within the SC
iii. To examine SC-related factors influencing SCP
iv. To assess current SCP metrics used in the sector

v. To propose a context-specific framework aimed at improving SC efficiency in the handloom industry

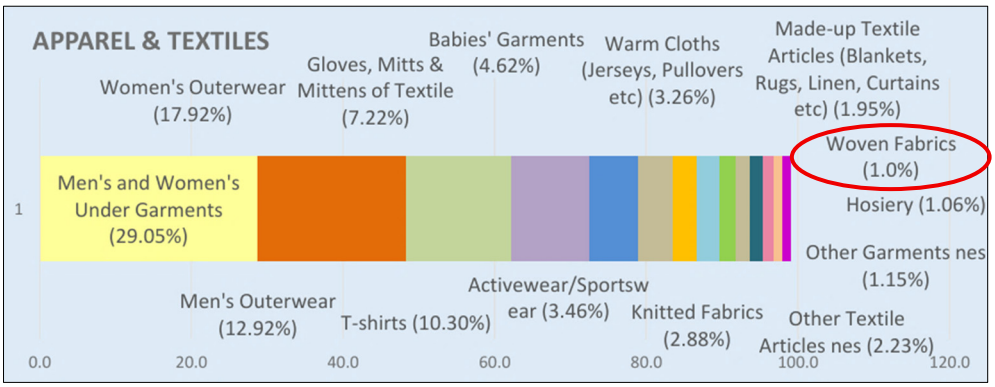

Figure 1: Contribution to the total export revenue by the handloom sector (2023)

This study makes both theoretical and practical contributions by developing a tailored SCP assessment model. Theoretically, it provides an analytical framework that combines SC mapping, performance evaluation, and improvement strategies, making it suitable for small-scale craft-based industries. Practically, the study's findings are intended to support policymakers and industry stakeholders in revitalising the handloom sector, improving livelihoods, and enhancing the competitive positioning of Sri Lankan handloom products in domestic and international markets.

2. LITERATURE REVIEW

This section examines existing research on SCP, including SCP measures, their importance, SCP in the handloom industry, and SC inefficiencies. By reviewing the relevant literature, this study aims to identify gaps and provide insights into improving the efficiency and competitiveness of handloom SCs.

2.1. Supply Chain Performance

SCP is commonly assessed through a dual focus on customer satisfaction and the costs associated with value delivery, reflecting the cross-functional and multi-actor characteristics inherent in logistics and operations [11]. SCP has been defined as the ability of the SC to carry out operations efficiently while minimising costs and fulfilling customer requirements [12]. In previous research, various approaches have been adopted, including the development of conceptual metric frameworks, surveys of commonly applied indicators, case study analyses, and quantitative models aimed at operationalising SCP assessments [13].

Although [14] conceptualised SCP through efficiency, responsiveness, and flexibility dimensions, the framework remains largely theoretical and lacks empirical validation in traditional industries. Similarly, [15] proposed strategic and operational performance dimensions; however, their study primarily reflected structured manufacturing environments. In contrast, limited attention has been paid to semi-formal state-supported production sectors such as handloom systems.

2.2. Supply Chain Performance Measures

Performance measurement quantifies the efficiency and effectiveness of SC operations. These measures are generally classified as qualitative or quantitative. Qualitative indicators, such as customer satisfaction, product quality, and SC resilience, are non-numerical, whereas quantitative metrics, such as fill rates, costs, inventory levels, and resource utilisation, are numerical. Commonly applied performance indicators in SC analysis include fill rates, order variance, the bullwhip effect, inventory variance, and total SC cost [16]. Performance measures are defined as metrics used to quantify the efficiency and/or effectiveness of actions within a process or system in relation to a specific target [17]. It has been emphasised that SCP is multidimensional. Therefore, multiple metrics are generally combined into a performance measurement system rather than relying on a single indicator. This approach is necessary to capture the different aspects of performance. From the perspective of Small and Medium-sized Enterprises (SMEs) and governance, performance measurement and management (PMM) has been described as an organised set of activities [18]. These activities include setting objectives and developing and using metrics to achieve them. While [19] reviewed extensive SCP measurement frameworks, they highlighted inconsistencies in metric selection across studies. Likewise, [11] noted that many performance measurement systems lack structural integration. Despite the abundance of proposed indicators, there is limited agreement on a standardised set of measures that can be adapted to small-scale traditional industries.

2.3. Importance of Measuring Supply Chain Performance

Systematic SCP measurements enable the identification of weaknesses, support continuous improvement, and sustain competitive advantages in complex environments [20]. The selection of appropriate metrics at the right time enhances decision-making [21]. The key benefits include progress monitoring, problem detection, recognition of achievements, and guidance for future improvements [13]. SCP is closely linked to organisational excellence by aligning strategy with operations, facilitating strategic decisions through key performance indicators (KPIs), providing end-to-end SC visibility, and promoting positive stakeholder

behaviour [22]. Moreover, it has been stated that without appropriate SC governance mechanisms, the effectiveness of performance measurement may be reduced [18]. Therefore, the value of measuring performance lies not only in data collection. Instead, it depends on the public's active use of performance information. Therefore, targets must be established. Therefore, monitoring processes must be implemented. Customer and supplier relationships should be guided by structured evaluations and collaboration. When such practices are applied, performance measures contribute more directly to supply chain improvements.

Although [20] emphasised the strategic importance of performance evaluation for competitiveness, their framework largely focuses on service-oriented logistics systems. Similarly, [21] linked performance measurement to competitive advantage, but their findings were based on large-scale industries. In contrast, the practical implications of SCP measurement in traditional and administratively governed sectors remain unexplored.

2.4. Supply Chain Performance in the Handloom Sector

Research on handloom and related craft sectors consistently highlights constraints directly relevant to the textile industry. In Bangladesh, factors such as competition from power looms, financial constraints, high-cost manual processes, changing consumer preferences, and the migration of skilled labour weaken competitiveness and disrupt the SC, necessitating targeted interventions to enhance SCP [23]. Across South Asia, limited networking, poor communication, low direct customer engagement, and insufficient design innovation have been found to hinder market responsiveness and SC efficiency. Ethical production and community collaboration have been suggested as strategies for improving SC resilience [4]. In the Sri Lankan context, stable infrastructure, skilled labour, and the integration of traditional crafts with modern market needs are seen as key enablers, while consistent policy and institutional support are recommended to strengthen the SC [25].

Moreover, existing studies on handloom systems primarily focus on socioeconomic sustainability and livelihood concerns rather than structured performance evaluations. For example, [26] examined the role of traditional textile production in supporting rural employment and cultural preservation, but did not adopt a formal SCP framework. Similarly, [23] discussed institutional and welfare-related challenges within the handloom sector, emphasising artisan livelihoods and market access rather than measurable operational performance indicators. In contrast, limited research has systematically evaluated SC determinants using structured analytical tools. This suggests a methodological gap in integrating formal SCP frameworks into traditional handloom contexts.

2.5. Supply Chain Inefficiencies in the Handloom Sector

A synthesis of the existing literature, corroborated by practitioner insights, reveals several recurring inefficiencies in the SCP in Sri Lanka's handloom sector. Key issues include dependence on intermediaries and limited direct market access [24], [4], variability and lack of standardisation in raw materials [1], [5], inventory bottlenecks and poor stock management [6], [27], and inadequate logistics and transport infrastructure [6], [28]. Additional challenges include demand uncertainty and market volatility [6], [29]; weak SC integration and coordination [30], [24]; limited information sharing and transparency [6], [31]; structural barriers, such as fragmented production and low entrepreneurial capacity [24], [4]; restricted access to finance [14], [1]; and reliance on manual low-tech processes that hinder scalability and responsiveness [5], [31].

2.6. Research Gap

The handloom industry in South Asia has been documented to some extent; however, many existing scholars present fragmented, largely descriptive accounts rather than systematic evaluations. In studies conducted in India, socioeconomic challenges, such as financial constraints and dependence on manual processes, have been identified. However, these barriers are rarely examined within an integrated SCP framework [7]. Consequently, the structural link between industry conditions, operational conduct, and performance outcomes is often unclear, limiting the theoretical coherence of these studies.

A notable weakness in the literature is the conflicting position on modernisation issues. On the one hand, the preservation of manual crafts is promoted to sustain "cultural authenticity." However, serious productivity gaps caused by limited technological integration have been emphasised [29]. These opposing views have rarely been reconciled in literature. However, a balanced analytical framework has seldom been proposed. Consequently, the tension between heritage preservation and operational efficiency remains insufficiently addressed in the literature.

Further inconsistencies were observed in the application of SCP metrics in the craft sector. In many cases, performance measurement models are adopted from large-scale apparel manufacturing processes. These models assume digital systems and reliable data availability. These conditions are generally absent in cottage-based enterprises. This mismatch reduces the validity of these findings. In addition, prior studies often followed a siloed approach. Functions such as sourcing or marketing are examined separately without assessing how upstream constraints, such as irregular yarn procurement, affect downstream outcomes, including customer satisfaction [23]. Therefore, interdependencies across the supply chain are underexplored.

However, methodological limitations are also evident. Many studies primarily rely on broad qualitative observations. The use of structured multicriteria decision-making tools remains limited despite their relevance in data-constrained environments, where expert judgment is essential [1]. Consequently, the analytical depth is restricted, and the robustness of the conclusions may be weakened.

Therefore, a review of the literature reveals that while various studies have explored the handloom sector in Sri Lanka and abroad, few have provided a structured and comprehensive assessment of SCP. Existing research has primarily addressed general challenges through qualitative observations without integrating SC mapping, performance metrics, and actionable strategies into a unified framework. Moreover, international SCP models have not been adapted to the specific context of Sri Lanka. Notably, no prior study has conducted an in-depth SCP analysis of the handloom SC in the Central Province, despite its significance in the industry. This study addresses this gap by developing a context-specific SCP assessment model that combines SC mapping, performance evaluation, and targeted improvements using provincial-level data.

3. METHODOLOGY

3.1. Research Design

A mixed-methods approach combining qualitative and quantitative elements was adopted in this study. Qualitative data were gathered through semi-structured interviews to identify the current SC structure and inefficiencies. To determine significant SC factors, the AHP method was employed, and to assess significant performance measures, a quantitative approach utilising a Likert-scale-based questionnaire was used.

The major stages of this study are illustrated in Figure 2. Through a comprehensive systematic review, SCP measures and factors affecting SCP were identified, and insights from industry experts were obtained to map the current SC structure and recognise existing inefficiencies. The identified measures and factors were subsequently categorised thematically, for example, operational and market-related factors. Based on the SCP literature and industry experts' recommendations, the most significant factors and measures were identified to design the AHP pairwise table and questionnaire. Using analytical methods and expert opinions on the SC structure and its inefficiencies, the final results and discussion were obtained.

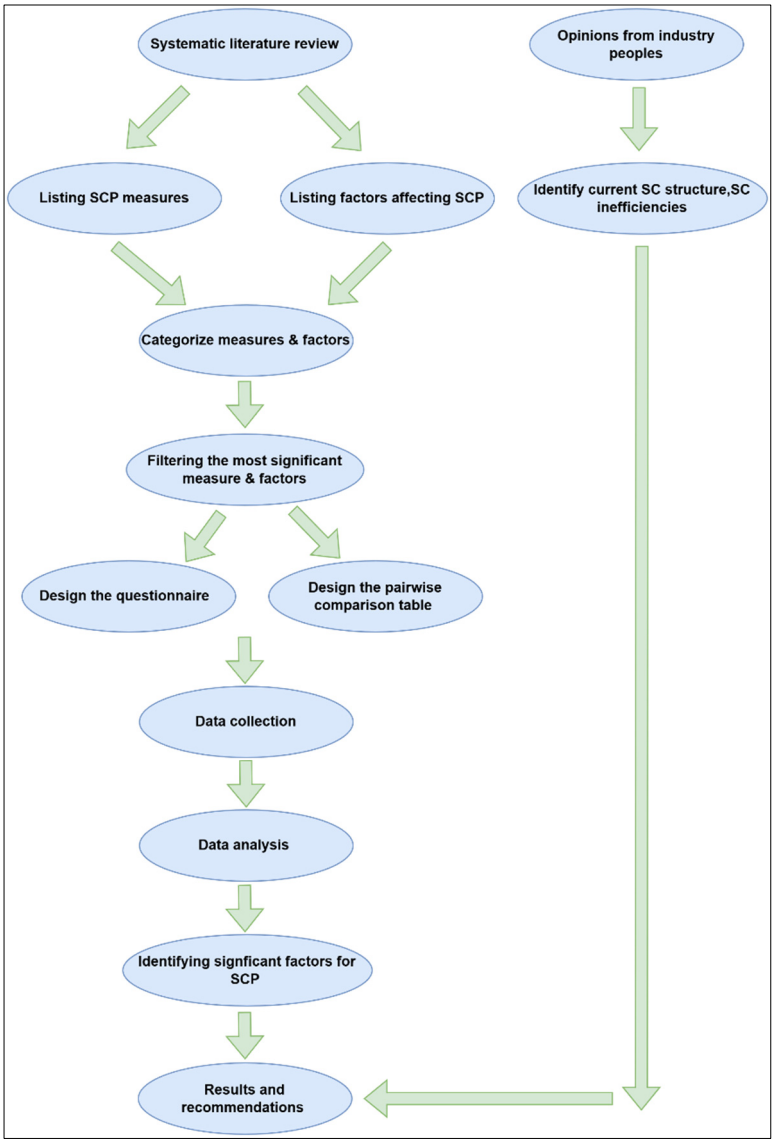

Figure 2: Research design

3.2. Analysis Model

Based on the most frequently cited factors and measures in the literature and insights from industry experts, 21 SC-related factors and 24 performance measures were identified as significant. These factors were subsequently categorised into four groups, whereas the performance measures were similarly classified into three distinct categories, as outlined in Figures 3 and 4.

The selection of the AHP categories and subfactors proceeded through a structured multistage process. Initially, a comprehensive systematic literature review of SCP

was conducted to identify commonly adopted performance dimensions and operational determinants relevant to the manufacturing and traditional production sectors. Frequently recurring constructs were grouped into broader functional domains that reflected procurement, production, distribution, and administrative controls. These domains align with the structural configuration of the handloom SC system in Central Province.

Subsequently, the preliminary list of factors was reviewed and refined through consultations with sector practitioners to ensure contextual relevance, eliminate redundancy, and capture operational realities specific to the handloom industry. This iterative screening process yielded four primary categories comprising 21 subfactors that collectively represent the critical determinants of SC performance in the sector.

No	Category	Code	Factors	(Asrol et al., 2017)	(Chand et al., 2020)	(Chang, 2022)	(Dhairiyasamy & Gabiriel, 2025)	(Ghadge et al., 2018)	(Ghasemzadeh & Pamucar, 2022)	(Kankam et al., 2023)	(Kathiyar et al., 2015)	(Kim & Lee, 2021)	(Magutu et al., 2015)	(Masengu et al., 2025)	(Moreira & Tjahjono, 2016)	(Munmun et al., 2023)	(Narsimhalu et al., 2015)	(Oubrahim et al., 2023)	(Petrillo et al., 2019)	(Tarasewicz, 2016)	(Thanki & Thakkar, 2018)	(Twamahoro et al., 2024)	(Twamahoro et al., 2024)	(Vanichchinchai, 2019)	(Walter, 2023)	(Wibowo & Sholeh, 2015)	(Yadav et al., 2024)	percentage of selected factors	Suggested by industry experts
1	Operational Factors	OF1	Decision-making methods	✓				✓			✓			✓	✓	✓			✓									30%	
2		OF2	Coordination between departments																										✓
3		OF3	Machine setups	✓	✓		✓		✓							✓	✓											25%	
4		OF4	Employee skills							✓	✓	✓													✓	✓	✓	✓	34%	
5		OF5	Resource allocation	✓	✓				✓	✓							✓		✓										25%	
6		OF6	Production planning	✓				✓			✓				✓			✓						✓	✓				30%	
7	Market factors	MF1	Product design & innovation				✓			✓	✓						✓					✓			✓			25%	
8		MF2	Cultural hertitage value perception by the customer																										✓
9		MF3	Market access																										✓
10		MF4	Government support																										✓
11		MF5	Information sharing frequency	✓			✓	✓				✓				✓			✓			✓		✓	✓			38%	
12	Transportation & Distribution factors	TDF1	Transportation infrastructure & access		✓				✓		✓							✓						✓				21%	
13		TDF2	Transportation vehicle																										✓
14		TDF3	Delivery reliability	✓	✓			✓				✓		✓		✓												25%	
15		TDF4	warehouse capacity																										✓
16		TDF5	Inventory levels & buffer stock			✓	✓			✓					✓							✓						21%	
17	Sourcing factors	SF1	Quality of raw materials	✓	✓	✓			✓	✓	✓				✓									✓			✓	✓	42%	
18		SF3	Raw material ordering method			✓		✓		✓				✓	✓														21%	
19		SF4	Supplier selection	✓					✓		✓	✓						✓									✓	✓	30%	
20		SF5	Number of alternative suppliers			✓		✓		✓				✓	✓														21%	
21		SF6	Supplier reliability			✓		✓					✓			✓				✓			✓						25%	

Figure 3: SC related factors

No	Category	Code	Supply Chain Performance Measure	(Asrol et al., 2017)	(Chand et al., 2020)	(Chang, 2022)	(Dhairyasamy & Gabiriel,	(Gardge et al., 2018)	(Ghasemzadeh & Pamucar,	(Kankam et al., 2023)	(Kativar et al., 2015)	(Kim & Lee, 2021)	(Magutu et al., 2015)	(Maseegu et al., 2025)	(Moreira & Tjahjono, 2016)	(Munnun et al., 2023)	(Narsimhalu et al., 2015)	(Oubrahim et al., 2023)	(Petrillo et al., 2019)	(Tarasewicz, 2016)	(Thanki & Thakkar, 2018)	(Uwamahoro et al., 2024)	(Uwamahoro et al., 2024)	(Vanichchinchai, 2019)	(Walter, 2023)	(Wibowo & Sholeh, 2015)	(Yadav et al., 2024)	percentage of selected measures	Suggested by industry experts
1		EM1	Profitability ratio	✓	✓			✓												✓	✓	✓		✓				30%	
2	Economic	EM2	Product cost per unit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100%	
3	Measures	EM3	Resource consumption per unit			✓			✓							✓					✓							21%	
4		EM4	Total logistic management cost		✓	✓		✓																✓	✓	✓		30%	
5		OM1	Idle time(Non-productive time) %			✓			✓				✓			✓										✓		21%	✓
6		OM2	Supplier lead time					✓			✓			✓							✓			✓		✓		25%	
7		OM3	Capacity utilization rate (%)	✓		✓												✓	✓				✓		✓			25%	
8		OM4	Employee productivity (units per employee per day)					✓				✓				✓				✓		✓					✓	25%	
9		OM5	Production flexibility rating	✓					✓			✓					✓		✓									21%	✓
10		OM6	Inventory turnover ratio (times per year)					✓					✓	✓			✓				✓		✓					25%	
11	Operational	OM7	Forecast accuracy rate (%)	✓	✓			✓	✓		✓		✓											✓				30%	
12	Measures	OM8	Warehouse space utilization(%)																										✓
13		OM9	Defect rate in production (%)			✓	✓		✓		✓						✓		✓								✓	30%	
14		OM10	Productivity ratio	✓																	✓			✓	✓	✓	✓	25%	
15		OM11	Training frequency																										✓
16		OM12	Waste and scrap percentage (%)												✓	✓		✓					✓	✓				21%	
17		OM13	Equipment Utilization ratio (%)	✓		✓					✓		✓									✓					✓	25%	✓
18		OM14	Employee turnover rate																										✓
19		CSM1	Consumer complaints						✓				✓						✓	✓	✓							21%	
20	Customer	CSM2	No of product range																										✓
21	Satisfaction	CSM3	Order Return Rate																									25%	✓
22	Measures	CSM4	Ontime delivery rate		✓		✓						✓		✓	✓	✓											21%	
23		CSM5	new-product launch frequency (per year)					✓	✓										✓		✓	✓						21%	
24		CSM6	Responsiveness	✓						✓		✓		✓									✓	✓			✓	30%	

Figure 4: SCP measures

3.3. Sampling Strategy

Nine experts were selected for the AHP analysis. Previous AHP studies in operational and SC contexts commonly utilise expert panels of five to fifteen participants when respondents possess specialised knowledge [32], [33]. Therefore, nine experts directly involved in procurement, dyeing, weaving, administration, auditing, and distribution were deemed sufficient to ensure informed pairwise comparisons.

To minimise role-based and hierarchical biases, experts were selected from diverse functional and administrative positions within the SC. The panel included procurement officers, weaving and dyeing specialists, planning officers, an internal auditor, a distribution officer, machine operators, and a provincial-level administrator (Table 1). This cross-functional composition ensured that no single operational domain dominated the evaluation. Additionally, the participants represented both senior (19–29+ years of experience) and relatively junior (3–7 years of experience) professionals, enabling balanced perspectives across experience levels. The inclusion of technical, financial, operational, and administrative roles reduced the likelihood of decision bias arising from a single functional or hierarchical group member.

Table 1: AHP analysis participant profiles

Expert id	Designation	Years of experience	Primary focus area
1	Development Officer (Grade I)	19+ years	Procurement, tender procedure handling
2	Development Officer (Grade III)	03+ years	Procurement, quality checking
3	Weaving Instructor (Grade III)	07+ years	Dying, weaving
4	Provincial Director	01+ years	Administrate
5	Development Officer (Grade I)	29+ years	Planning, developing
6	Internal Auditor	03+ years	Accounting
7	Management Service Officer	04+ years	Material storage, distribution
8	Machine, Die Operator	28+ years	Weaving machine operations, dying operations
9	Weaving Instructor	16+ years	Product sales

Twenty experts evaluated 24 performance measures using a structured Likert-scale questionnaire to assess SCP measurements. In perception-based performance assessments within bounded sectoral contexts, a sample of 15–30 knowledgeable respondents is considered sufficient to capture collective expert agreement, particularly when the population of qualified experts is limited [34], [35]. The handloom sector in Central Province operates within a defined administrative structure; therefore, the 20 selected participants represent a substantial proportion of key functional roles.

To minimise selection bias, experts were drawn from multiple hierarchical levels and functional areas, including procurement officers, development officers, dyeing operators, weaving instructors, storage managers, accountants, internal auditors, and provincial administration with different experience levels. This role diversification reduces the risk of the dominance of a single professional category.

3.4. Data Collection Instruments

3.4.1. Analytic hierarchy process pairwise comparison tables

To identify and prioritise SCP factors, expert opinions were collected through a pairwise comparison table using Saaty's 1–9 fundamental scale [a pairwise comparison table for the main categories in the local language is attached in Appendix A]. Comparisons were first structured among the main factor categories, followed by the subfactors within each category. Individual judgments were compiled into matrices and aggregated to derive the relative weights. Consistency Ratios (CR) were calculated for each expert to verify the logical consistency of their responses [32].

3.4.2. Structured questionnaire

A 24-item instrument was developed based on the study's SCP framework, encompassing economic, operational, and customer satisfaction categories. All items were positively worded, allowing for higher agreement to reflect greater adoption of the respective SCP measures. To ensure clarity and accessibility, the questionnaire was translated into Sinhala and administered using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

To ensure content validity, an academic research expert reviewed the questionnaire to assess its clarity, relevance, and contextual appropriateness. A small-scale pilot test was conducted with three industry practitioners to evaluate comprehensibility and word choice, resulting in minor refinements to the questionnaire. Translation accuracy was verified through an expert review to ensure semantic consistency. Because the items represented multiple distinct performance dimensions rather than a single latent construct, the analysis focused on the descriptive assessment of individual indicators rather than composite scale modelling. [The questions used in the questionnaire are provided in Appendix B, in both the local language and English]

3.5. Data Analysis Approaches

3.5.1. Analytical hierarchy process

AHP was selected because of the small sample size and the need to rigorously capture expert judgment. Through hierarchical decomposition, experts' pairwise comparisons were converted into priority weights. The AHP effectively integrates qualitative and quantitative evidence and is widely used in complex decision-making scenarios [33]. Consistency of responses was assessed using the CR (Consistency Ratio), calculated as below (1),

$$CR = CI/RI \quad \text{---------- (1)}$$

where:

- RI – Random Index

CI (Consistency index) calculated as below (2),

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \text{---------- (2)}$$

where:

- λ max - Maximum average value
- n – Order of Matrix

The value of the RI can be selected from the random consistency index table [Table 2] according to the value of "n".

Table 2: Random consistency index table

Order of matrix(n)	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0.00	0.00	0.52	0.89	1.11	1.25	1.32	1.41	1.45	1.49

Comparisons with acceptable CR values were deemed to be logically consistent [32].

3.5.2. Ordinal analysis

Responses to the 24 Likert-scale items were analysed using descriptive statistics, including mean values, which are suitable for ordinal data. This approach aligns with the recommended practices for analysing ordered-category responses [34], [35]. All computations were performed using Microsoft Excel.

Using ordinal analysis, this study assessed perceived SCPs using expert-based ordinal evaluations rather than objective archival KPI data. Given the informal operational structure and limited availability of systematically recorded performance statistics in the handloom sector, structured expert judgment was adopted as a practical and context-appropriate evaluation method. Therefore, the findings reflect the collective perceptions of practitioners regarding current performance conditions rather than audited quantitative performance metrics.

4. DATA ANALYSIS AND DISCUSSION

This section presents the results and interpretation of the AHP, ordinal analysis, and qualitative expert insights used to evaluate SCP in Sri Lanka's handloom industry. It discusses key performance factors, assesses current SC efficiency levels, and integrates these findings to identify practical strategies for improving overall SC effectiveness.

4.1. Current Supply Chain Structure of the Handloom Sector in Sri Lanka

The lack of a comprehensive SC map of Sri Lanka's handloom industry is a key gap. Based on expert interviews, an SC mapping exercise was conducted to outline the material, information, and financial flow. The resulting diagram depicts the SC structure of a single province and reflects the broader national patterns.

Most raw materials, particularly yarn, are imported from India, with occasional sourcing from China and South Korea based on cost and availability. The Ministry of Industry and Commerce manages procurement through formal tender processes, designating separate suppliers for yarns and dyes. Once procured, materials are sent to the provincial main operation centre (for instance, the Haragama centre in the

Central Province) for inspection and testing by a technical committee and the Institute of Textile and Apparel.

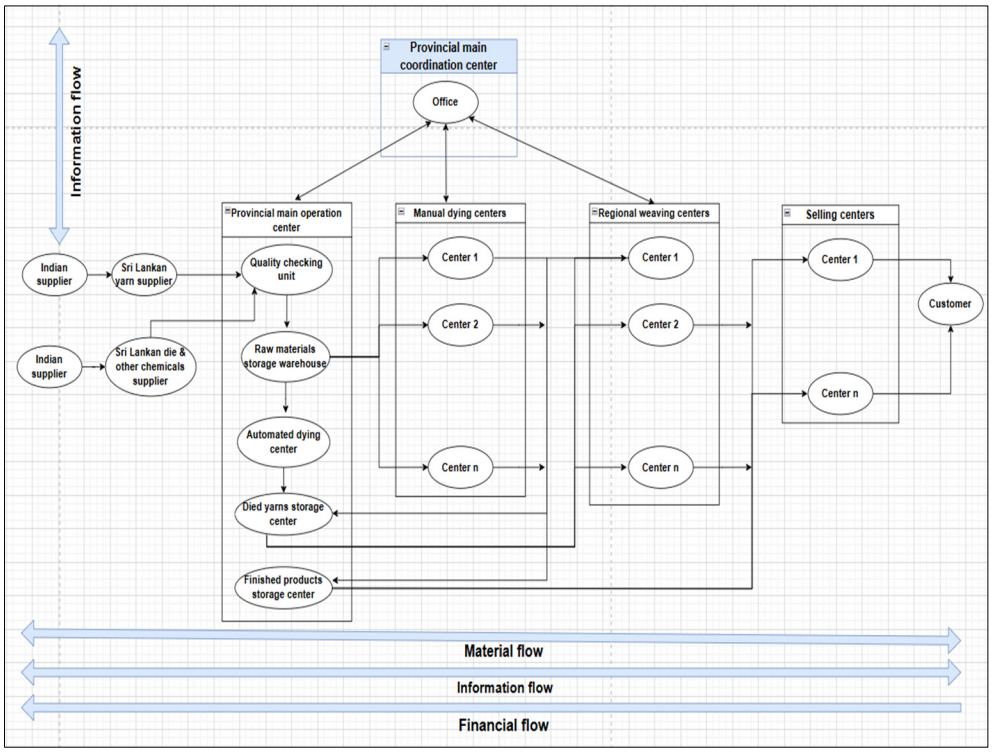

Figure 5: SC structure of handloom

Approved yarns are distributed to automated and manual dyeing centres. The dyed yarns are then stored and allocated to regional weaving centres based on demand. Dedicated vehicles are used to transport materials and finished goods. Weaving centres specialise in products such as sarongs, sarees, and bed sheets. Completed items are returned to the provincial centre, stored, and later distributed to provincial retail outlets *(Ms G. Fernando, Technical Committee Member & Procurement Officer, personal communication, July 18, 2025).*

4.1.1. Key supply chain partners

After mapping, the key SC partners involved in the SC structure were identified.

Upstream suppliers

- Grey yarn suppliers- Contracted via tenders to import and hold “grey yarn” in bulk, then release to provincial operation centres as production demands arise *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025).*

- Dye/chemical suppliers- Tendered importers that also serve larger apparel firms; maintain substantial inventories to meet cross-industry demand (*Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025)*.

Government & institutional partners

- Ministry of Industry and Commerce- Policy and sector development; streamlining raw material supply; market-access facilitation and exhibitions *(Anonymous participant, personal communication, August 7, 2025)*.
- Provincial "Textile Department"- Central coordination hubs that distribute inputs, manage transport for inbound/outbound flows, keep accounts, and run technical committees *(Ms G. Fernando, Technical Committee Member & Procurement Officer, personal communication, July 18, 2025)*.
- SLITA (quality assurance)- Receives yarn/dye samples after preliminary checks; conducts lab testing (count/strength/chemical composition), reports results, and is paid for services *(Ms G. Fernando, Technical Committee Member & Procurement Officer, personal communication, July 18, 2025).*
- Audit departments–ministry, provincial, and internal audits verify procurement, usage, financial, and chemical use percentages to ensure compliance and transparency.

Production & operational partners

- Provincial operation centres - storage and distribution for yarn/chemicals; machine distribution/repair (in-house carpenter); deteriorated wood reused as fuel for manual dyeing; high-throughput yarn storage *(Mr C. Kumara, Storage Operator, personal communication, July 18, 2025)*.
- Automated dyeing centres (provincial). Boiler-based, automated chemical blending per standard ratios; batch dyeing triggered by regional requests; yarns air-dried and returned to store *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025)*.
- Manual dyeing centres (districts). Wood-fired, labour-intensive units (e.g., four in Central Province) that remain essential to throughput *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025).*

Transportation & logistics partners

- Inbound (supplier-managed) and outbound (provincial-managed) logistics- Suppliers move raw materials to provincial centres and use couriers in emergencies; provinces allocate a small fleet (e.g., three cabs and one lorry) and a transport officer for routing and driver assignment *(Mr A. Kumara,*

machine/dye operator, personal communication, 25 July 2025; Ms. G. Fernando, Technical Committee Member & Procurement Officer, personal communication, July 18, 2025).

Retail & distribution partners

- Provincial sales outlets are also included. Finished goods routed from weaving centres reach provincial stores for selling; revenues recorded by provinces and remitted to the government *(Ms G. Fernando, Technical Committee Member & Procurement Officer, personal communication, July 18, 2025)*.
- Exhibitions/temporary centres- Seasonal events used to raise visibility and boost sales; high success reported in Kandy and Colombo *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025)*.

Collectively, these partners shape the key levers for SC coordination, quality assurance, and market access, which are crucial for strengthening SCP in the sector.

4.1.2. Identified supply chain inefficiencies

A series of SC inefficiencies was identified from the literature and verified through expert interviews in the handloom context.

A key structural issue is the lack of an integrated SC, as each province operates independently in importing and distributing raw materials. This decentralisation hinders coordination and resource optimisation. Raw material supply remains inconsistent owing to tender-based procurement, trade disruptions, and cost-driven supplier variation, often resulting in delays in yarn *production (Ms A. Rathnayaka, weaving instructor, personal communication, July 24, 2025)*.

Transportation inefficiencies include driver shortages, frequent vehicle breakdowns, and delays due to bureaucratic maintenance procedures. Poor road conditions and a weak communication infrastructure further affect rural accessibility (*Ms T. Rathnayaka, Transport Officer, personal communication, September 9, 2025)*.

Outdated weaving machinery and manual dyeing processes also contribute to low productivity and extended lead times *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025).*

Quality checks and administrative tasks are heavily manual, resulting in delays in material approval, inventory tracking, and transportation (*Mr C. Kumara, Storage Operator, personal communication, July 18, 2025; Ms T. Rathnayaka, Transport Officer, personal communication, September 9, 2025).*

Human capital shortages, especially among younger workers, have also been observed, with declining engagement due to low income and motivation *(Ms A. Rathnayaka, weaving instructor, personal communication, July 24, 2025)*; *(Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025)*

Marketing remains underdeveloped, with no dedicated promotional efforts or customer-engagement strategies. Sales mainly rely on loyal customers and occasional exhibitions, while product designs have not been adapted to meet the changing international market demands *(Ms N. Kodithuwakku, Weaving instructor, personal communication, July 25, 2025; Mr A. Kumara, machine/dye operator, personal communication, July 25, 2025).*

4.2. Analytical Hierarchy Process Analysis for Prioritising Supply Chain Factors

To identify and prioritise the most significant SC-related factors affecting SCP in Sri Lanka's Central Province handloom sector, an AHP model was developed, as shown in Figure 6. This approach was selected because of its suitability for small expert samples and its ability to rigorously capture informed judgments in complex decision-making contexts [33], [36].

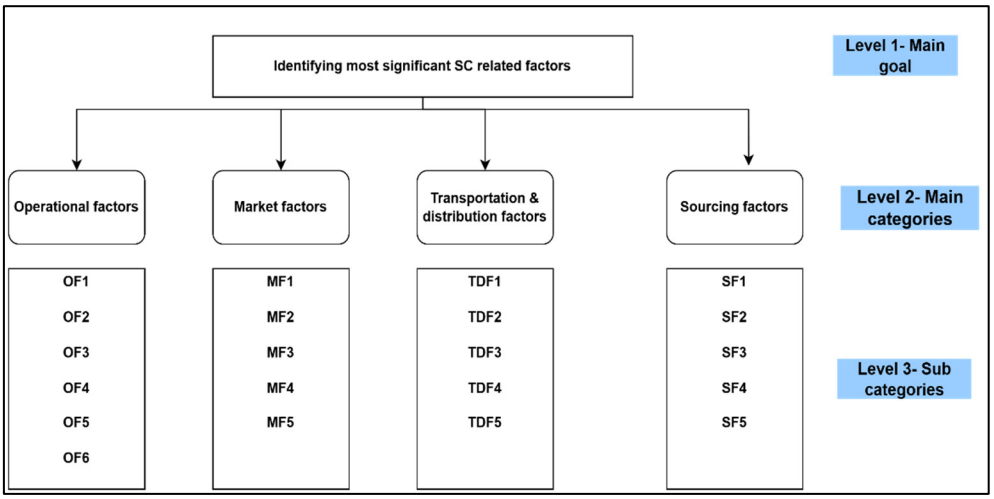

Figure 6: AHP model

Pairwise comparisons were conducted using Saaty's 1–9 fundamental scale. The experts evaluated the relative importance of the main factor categories and the sub-factors within each. Following the collection of individual judgments, the aggregation process was carried out using the Weighted Geometric Mean Method (WGMM), which is recognised as the most widely applied technique for judgment aggregation [37]. Once the main categories and each sub-category were combined into a single

aggregated matrix, the CR for each aggregated matrix was checked and maintained under 0.1 acceptable level because consistency checking should be applied whenever a pairwise comparison matrix is used in analysis, whether individual or aggregated [38], as shown in Table 3.

Table 3: CR ratios for each aggregated matrix

Aggregated Matrix	CR
Main categories	0.0240
Operational factors	0.0018
Market factors	0.0133
Transport & distributing factors	0.0266
Sourcing factors	0.0110

Local and global weights were calculated to determine the relative importance of each factor in the model. Local weights represent a factor's significance within its category, whereas global weights reflect its overall priority across the decision-making framework. Based on these weights, the main factors and subfactors were ranked from most to least significant (Table 4).

Table 4: Final weights of SC related factors

Main Factors (Global Weights)	Sub Factors	Local Weights (Sub)
Sourcing (0.37850)	Supplier Selection	0.293
	Quality of Raw Materials	0.262
	Supplier Reliability	0.197
	Raw Material Ordering Method	0.164
	Number of Alternative Suppliers	0.081
Operational (0.23856)	Resource allocation	0.240
	Decision-making methods	0.225
	Employee skills	0.152
	Coordination between departments	0.151
	Production planning	0.150
	Machine setups	0.079
Transportation & distribution (0.22816)	Warehouse capacity	0.245
	Transportation infrastructure & access	0.243
	Inventory levels & buffer stocks	0.190
	Delivery reliability	0.167
	Transport vehicle	0.153

Main Factors (Global Weights)	Sub Factors	Local Weights (Sub)
Market (0.15476)	Cultural heritage value perception by the customers	0.252
	Market access	0.251
	Product design & innovation	0.200
	Government support	0.179
	Information sharing frequency	0.115

Based on the AHP analysis, the SC-related main categories in the handloom sector of the Central Province were prioritised in the order of sourcing > operations > transportation and distribution > market factors. This order reflects the relative importance of these categories in determining SCP.

Within the sourcing category, ranking indicates that supplier selection is the most critical determinant of sourcing performance, followed closely by ensuring raw material quality. Supplier reliability and ordering methods were of moderate importance, whereas the number of alternative suppliers ranked lowest, likely reflecting the limited availability of qualified suppliers in the current context.

In the operational category, the rankings highlight that effective resource allocation and decision-making methods are the most critical requirements for operational efficiency in the sector. Although employee skills, interdepartmental coordination, and production planning were also recognised as important, they ranked slightly lower. The machine setups were given the lowest priority.

In the transportation and distribution category, warehouse capacity ranked the highest, highlighting the sector's reliance on adequate storage for managing raw materials and finished goods. Transport infrastructure, access, and buffer stock levels were deemed essential for mitigating disruptions. Although delivery reliability and vehicle availability were considered less influential, they remained necessary for ensuring smooth distribution.

Although marketing is important for the sector, it is prioritised as a less influential factor in SCP. The findings highlight that customer perception of cultural heritage is a significant strength, with traditional design authenticity as the foundation of demand. Market access and product innovation were considered moderately important, indicating the need for better distribution networks and adaptation to evolving market trends. Government support and information sharing were ranked lower, suggesting that, while contributing to performance, they are not considered primary drivers of marketing effectiveness.

4.3. Ordinal Analysis for Assessing Current Supply Chain Performance Measures in the Sector

As discussed in the sample strategy section (3.3), the expert panel was diverse, ensuring that both strategic and operational perspectives were considered. Forty per cent of the respondents possessed over 20 years of industry experience, while 35% had 11–20 years, and 25% had less than 10 years, as illustrated in Figure 7.

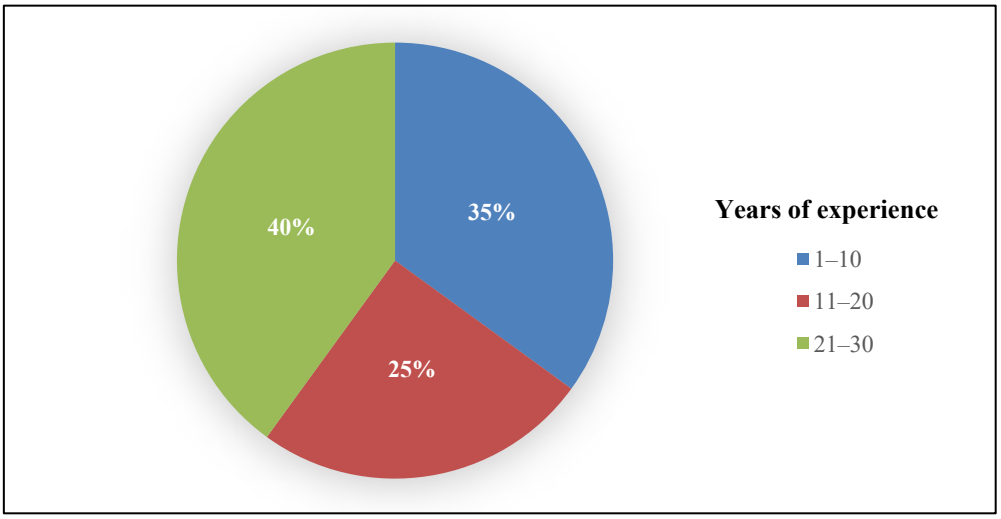

Figure 7: Experts service experience analysis

Designation diversity included development officers (30%), weaving instructors (25%), management and industry officers (10%), accountants, internal auditors, technical staff, directors, and weaving instructors (5%). This balance enhances the validity of ordinal assessments by integrating insights from multiple hierarchical levels of the SC (Table 5).

Table 5: Distribution of experts by designation

Designation	Percentage (%)
Development Officer	30
Weaving Instructor	25
Industry Development Officer	10
Management Officer	10
Accountant	5
Internal Auditor	5
Machine and Die Operator	5
Provincial Director	5
Weaving Teacher	5

4.3.1. Mean analysis

In this study, the mean value was used as the principal indicator for ordinal data analysis because it provided the most representative single value for identifying the overall level of agreement among experts. The mean also facilitates a straightforward interpretation and a clear visual presentation of the results, aligning with the study's objective of summarising experts' perceptions across economic, operational, and customer satisfaction dimensions. As Marshall and Jonker (2010) [39] highlighted, descriptive statistical analysis, such as the mean, is ideal for summarising and interpreting data in small expert populations, which suits the exploratory nature of this research.

Based on category-wise analysis and individual assessments across the economic, operational, and customer satisfaction dimensions, a mean analysis was conducted to derive SCP measure-based insights for the handloom sector.

As shown in Figure 8, the mean analysis of the main categories reveals that economic (3.625) and customer satisfaction (3.55) are perceived more positively than operational (3.382), indicating that cost-related and customer-facing aspects of SCP are seen as more effective than day-to-day operational activities. Economic measures were viewed as adequate. Similarly, customer satisfaction measures received favourable ratings. However, the operational dimension was considered weaker.

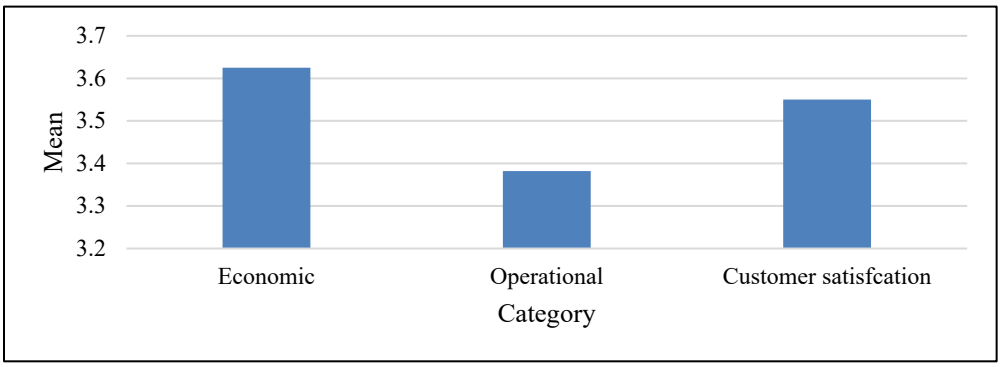

Figure 8: Category-wise overall mean analysis

Figure 9 shows that within the economic measures category, experts rated resource consumption per unit the highest (mean = 3.8), followed by total logistics management cost (mean = 3.7) and product cost per unit (mean = 3.6). Profitability ratio received the lowest mean score (mean = 3.4). These results suggest that the sector is efficient in terms of resource use and logistics management; however, profitability remains modest, likely due to pricing constraints, small-scale operations, and production inefficiencies. While economic measures are generally adequate,

improving profitability will require enhanced production efficiency and value addition.

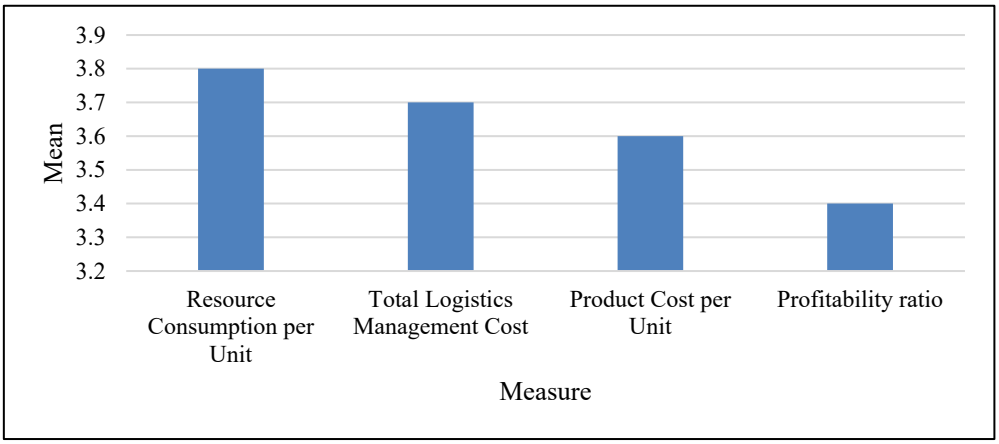

Figure 9: Mean ratings of economic category

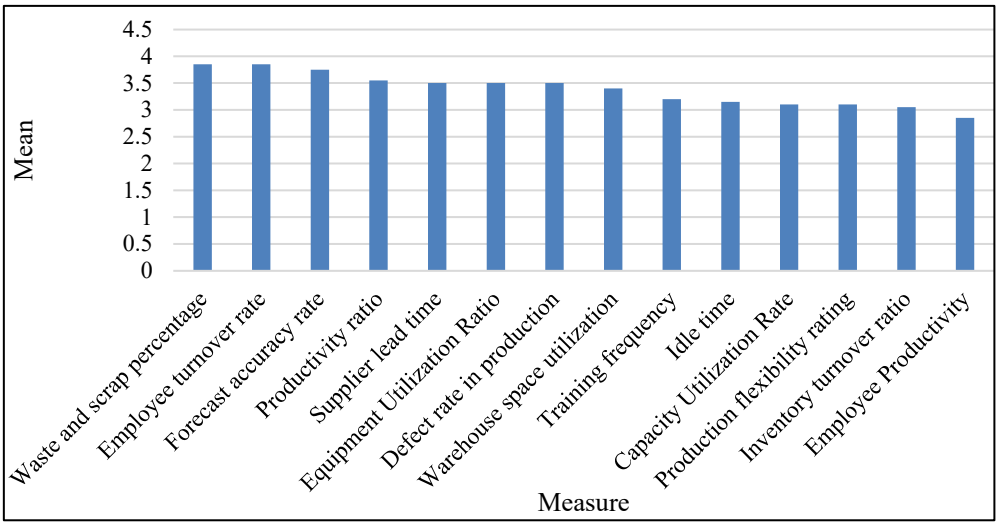

Figure 10: Mean ratings of operational category

As shown in Figure 10, experts rated waste and scrap percentage, employee turnover rate, and forecast accuracy as the highest among operational measures, with mean scores of nearly 3.8, indicating satisfactory control over material use, workforce stability, and demand forecasting. The productivity ratio, supplier lead time, and equipment utilisation received moderate scores (~3.5), suggesting that process standardisation and coordination can be improved. Lower scores were observed for training frequency, employee idle time, capacity utilisation, and other efficiency measures (means ranging from 3.0 to 2.85), indicating weaknesses in workforce development, process adaptability, and throughput efficiency. Overall, while basic

production stability and quality control are maintained, inefficiencies in labour productivity, capacity use, and process flexibility hinder SCP improvement. A strategic focus on skill development, process optimisation, and capacity planning is essential for strengthening operational capabilities.

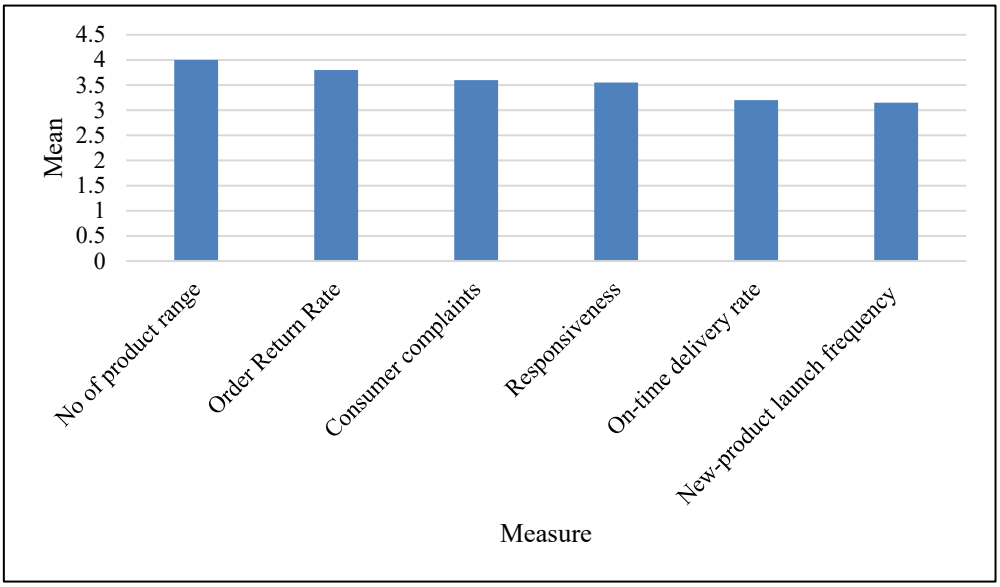

Figure 11: Mean ratings of the customer satisfaction category

As shown in Figure 11, experts assessed the number of product ranges as the highest (mean = 4.0), indicating strong agreement that the handloom sector offers diverse products that meet customer preferences. The order return rate (mean = 3.8) and consumer complaints (mean = 3.6) also received favourable ratings, reflecting satisfactory product quality and post-sale service. Moderate scores were observed for responsiveness (mean = 3.55), on-time delivery rate (mean = 3.2), and new product launch frequency (mean = 3.15), suggesting that while customers are satisfied with product variety and quality, delivery reliability and innovation need improvement. Overall, the analysis indicates that while the sector enjoys strong market acceptance, enhancing service performance, adaptability, and product development is crucial for maintaining competitiveness and improving SC responsiveness.

4.3.2. Percentage distribution of expert ratings for each question

Although mean values were calculated to facilitate comparative interpretation across the 24 performance measures, the analysis did not rely solely on arithmetic averages. Given the ordinal nature of the 5-point Likert-scale data, the percentage distribution of expert responses (Figure 12) is presented to provide a nonparametric summary of the overall agreement patterns. The graphical distribution allows for the direct observation of central tendency, dispersion, and concentration of responses across

scale categories without assuming equal-interval spacing between response levels. This combined approach enhances interpretative transparency and ensures that conclusions are grounded in the actual response structure, rather than solely on aggregated mean values.

Figure 12: Percentage distribution of expert ratings for each question

4.4. Strategic Framework for Enhancing Supply Chain Performance

Based on the integrated findings from AHP prioritisation, ordinal performance analysis, and qualitative insights, a context-specific strategic framework was developed to improve SC efficiency in the Sri Lankan handloom industry. The framework focuses on strengthening four critical dimensions: sourcing, operations, transport and distribution, and marketing, which together determine the overall SCP.

4.4.1. Stabilise the sourcing function

The AHP results identified sourcing as the most influential factor in determining SCP. The framework emphasises establishing strategic partnerships with direct foreign suppliers (particularly in India and China) to ensure consistent access to quality yarns and dyes, supported by government facilitation of these partnerships. Maintaining a backup supplier list and implementing a basic supplier performance portfolio (SPP) system using digital tools, such as Excel, is recommended to enhance reliability, visibility, and accountability in raw material procurement.

This recommendation is considered a high-priority, high-feasibility option in the short to medium term because it primarily requires coordination improvements rather than heavy capital investments. Establishing direct supplier partnerships and maintaining a structured SPP can be implemented at a relatively low financial cost using existing administrative capacity and basic digital tools. The Ministry of Industries should facilitate negotiations with foreign suppliers and policy-level approvals, while the Provincial Department can operationalise supplier monitoring and maintain the SPP system. Provincial procurement officers are responsible for implementation at the operational level.

4.4.2. Strengthening operational efficiency

Ordinal analysis reveals operational weaknesses in productivity, flexibility, and capacity utilisation. To address these issues, the framework proposes the following:

- Developing a nationally integrated SC network across provinces for shared resources, asset pooling, and human capital deployment.
- Introducing semi-automated machinery (e.g., yarn winding machines and limited-power looms) to reduce manual inefficiencies.
- Establishing a multi-level decision-making structure (strategic, tactical, and operational) and promoting workflow mapping to document tacit expertise and minimise process dependence on individual employees.
- Implementing a weaver–entrepreneur vocational training model that combines traditional craft skills with business, marketing, and digital literacy to attract and retain younger generations

Operational restructuring is a high-impact but phased-priority intervention, given its moderate-to-high financial and institutional requirements. Introducing semi-automated machinery and establishing a nationally integrated SC network requires significant capital investments, particularly in equipment procurement and training. Therefore, this recommendation is moderately feasible. The Ministry of Industries should lead capital allocation and policy direction, while the Provincial Department should oversee coordination across districts. Vocational training initiatives may

require collaboration with technical education authorities and private sector partners to ensure sustainability. However, workflow mapping and structural reforms are low-cost and immediately feasible under provincial administration.

4.4.3. Improve transport and distribution functions

The AHP results placed transport and distribution as the next priority, following the identification of operational and transport barriers as a significant source of SC inefficiency through qualitative analysis. The key recommendations are as follows:

- Expanding transport capacity through rental vehicle integration to manage delivery fluctuations was also suggested.
- Implementing a Transport Performance Monitoring System (TPMS) with key metrics such as lead time, utilisation rate, and cost per delivery.
- The introduction of a simple digital inventory management system to replace manual recordkeeping and improve inventory turnover and responsiveness is recommended.

Improvements in transport and distribution are considered moderate-cost and operationally feasible in the short term. Rental vehicle integration and digital inventory systems require limited infrastructure investment but strong administrative coordination to be effective. A TPMS can be implemented using basic digital platforms, making it financially feasible. The Provincial Department of Industries should take primary responsibility for operational execution, whereas regional centres manage day-to-day monitoring. The Ministry's role would remain supportive, focusing on policy alignment and, where necessary, on funding approval.

4.4.4. Strengthen the marketing function

Marketing was primarily identified as an underdeveloped supporting factor influencing SCP. The framework proposes:

- Therefore, establishing a dedicated marketing division for branding, digital promotion, and customer engagement is essential.
- Developing a customer-driven design loop that translates market feedback into product innovation is essential.
- Expanding into foreign markets through exhibitions, trade fairs, and digital storytelling to highlight the sector's cultural authenticity.
- Creating a centralised national marketing coordination mechanism to unify regional efforts under a single brand identity enhances market visibility and profitability.

Marketing enhancement represents a strategic, long-term priority with potentially high returns but requires structured investment and institutional reform. Establishing a dedicated marketing division and expanding into foreign markets may involve moderate financial costs, particularly in branding, exhibitions, and digital promotion. However, digital storytelling and customer feedback integration are relatively low-cost and immediately actionable. The Ministry of Industries should coordinate national branding and foreign market entry, whereas the Provincial Department manages regional promotion and customer engagement initiatives. Collaboration with private sector actors, designers, and export development agencies would significantly enhance the feasibility and sustainability of the project.

4.4.5. Summarised strategic framework for improving supply chain efficiency

A consolidated summary of the strategic recommendations and interventions to improve SC efficiency in Sri Lanka's Central Province handloom sector is presented in Table 4. The framework categorises the recommendations under four key functional areas: sourcing, operations, transportation and distribution, and marketing, as used in the study. For each recommendation, the corresponding SC inefficiencies identified through expert interviews are mapped, and the specific SCP measures addressed by the intervention are clearly indicated. This strategic framework serves as a comprehensive reference for guiding targeted improvements across the sector.

Table 6: Summarised strategic framework for improving SC efficiency

SC Category	Suggested Recommendations	SC Inefficiencies Mapped	SCP Measures Addressed within the Recommendation
Sourcing	Establish strategic partnerships with direct suppliers	Lack of a consistent raw material supply	Supplier lead time, profitability ratio, total logistic cost, product cost per unit
	Maintain a backup supplier list	Lack of a consistent raw material supply	Supplier lead time, forecast accuracy rate
	Implement a simple SPP	Lack of a consistent raw material supply	Supplier lead time, forecast accuracy rate, and total logistic cost
Operational	Formalising an integrated supply chain framework	Lack of an integrated supply chain	Total logistic cost, resource consumption per unit, capacity utilisation rate, waste and scrap %, equipment utilisation rate, profitability ratio, product cost per unit, production flexibility rate
	Implement multi-level decision-making	Production inefficiencies, quality checking inefficiencies	Addressed all the measures

SC Category	Suggested Recommendations	SC Inefficiencies Mapped	SCP Measures Addressed within the Recommendation
	Adopt operational workflow mapping	Mapped for all SC inefficiencies identified	Addressed all the measures
	Implement a modernised vocational training	Human capital constraints	Training frequency, employee productivity, order return rate, employee turnover rate, and idle time
	Establish a TPMS	Manual paperwork, transport barriers	Productivity ratio, supplier lead time
	Implement a simple inventory management system	Manual paperwork	Productivity ratio, inventory turnover ratio, responsiveness, capacity utilisation rate, forecast accuracy rate, and warehouse capacity utilisation
Marketing	Establish a dedicated marketing section	Poor or outdated marketing and sales channels	Profitability ratio
	Introducing a customer-driven design loop	Poor or outdated marketing and sales channels	Customer complaints, new product launch frequency per year, order return rate, on-time delivery rate, and production flexibility
	Expand into foreign markets	Poor or outdated marketing and sales channels	Profitability ratio, number of product ranges, and new product launch frequency per year
	Create a centralised marketing coordination mechanism	Poor or outdated marketing and sales channels	Profitability ratio, responsiveness, production flexibility

5. CONCLUSION

This study examined the factors influencing SCP in Sri Lanka's handloom industry, focusing on government-operated centres in the Central Province. Using an integrated methodological approach that combines SC mapping, AHP, ordinal performance assessment, and qualitative expert insights, this study systematically evaluated SCP determinants and performance measures in a traditional, data-constrained industrial context. The findings indicate that sourcing-related factors are the most influential drivers of SCP, followed by operational, transportation, distribution, and market-related factors. While the economic and customer satisfaction dimensions show relatively satisfactory performance, operational efficiency, flexibility, and innovation remain weak. These insights informed the development of a context-specific strategic framework to improve SC efficiency without compromising the sector's cultural and institutional characteristics in the region.

5.1. Academic Implications

This study makes a clear contribution to the SCP literature by addressing the limited understanding of SCP concepts and performance metrics in the Sri Lankan handloom industry. Prior research has largely overlooked this sector, resulting in a lack of empirical evidence and context-sensitive analytical frameworks for the sector. By providing structured empirical insights into SCP factors and measures specific to a traditional craft-based industry, this study helps bridge a critical academic gap. The key academic contribution lies in the development and validation of a hybrid SCP assessment framework that integrates AHP-based prioritisation with ordinal, perception-based performance measurement and qualitative analysis. This approach demonstrates how SCP frameworks, typically designed for data-rich manufacturing environments, can be effectively adapted to small-scale, informal, and heritage-based industries, where operational data are scarce. Thus, this study extends the theoretical applicability of SCP models and offers a replicable methodological reference for future research in similar contexts.

5.2. Practical Implications

From a practical perspective, this study provides policymakers and practitioners with actionable guidance to enhance handloom SC efficiency. The findings highlight the need to stabilise raw material sourcing through strategic supplier partnerships, improve operational coordination across provinces, introduce low-cost digital monitoring tools for logistics and inventory management, and strengthen human capital through targeted vocational training. The proposed strategic framework offers a feasible roadmap for improving productivity, responsiveness, and profitability within existing administrative and resource constraints.

5.3. Limitations and Future Research Directions

This study relied primarily on expert perception-based data owing to the absence of systematically recorded operational performance data, which may limit the objectivity of certain SCP assessments. Additionally, the geographical focus on government-operated centres within a single province and the relatively small expert sample size restrict the generalisability of the findings. The use of qualitative interviews and ordinal scale evaluations may also introduce subjectivity, despite providing valuable contextual insights.

Future research could extend this work by incorporating methodological triangulation, such as combining AHP with other multi-criteria decision-making techniques or integrating limited operational data, where available. Expanding the scope to include privately owned and community-based handloom enterprises across

multiple provinces would further enhance the comparative validity and generalisability.

In conclusion, this study provides a structured, context-sensitive, and replicable framework for assessing and improving SCP in traditional industries, offering valuable insights for academic research and evidence-based policy development.

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APPENDICES

Appendix A:

Excerpt from the AHP pairwise table to compare main categories.

I. Operational Factors

This includes management of internal departments, department processes, production strategies, machinery, financial operations, and all resource management activities within the organisation.

II. Marketing-Related Factors

This includes different clothing styles offered to customers, cultural and traditional sentiments regarding the handloom industry, market opportunities for the sector, and information sharing among stakeholders.

III. Factors Related to Transportation and Distribution

This includes vehicles, access to roads, timely transportation, adequate buffer stocks, and storage capacity.

IV. Sourcing related factors

This involves the quality of raw materials, the selection of good suppliers, the number of alternative suppliers, and the reliability of suppliers.

Comparison of Main Factors

To determine significant factors affecting to the handloom supply chain

Number	1st factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2nd factor
1	Operational																		Marketing
2	Operational																		Transportation and distribution
3	Operational																		Sourcing
4	Marketing																		Transportation and distribution
5	Marketing																		Sourcing
6	Transportation and distribution																		Sourcing

Appendix B:

Questions used to evaluate SCP measures.

Question	Code	Category	Measure	Question
1	EM1	Economic measures	Profitability Ratio	Our handloom business makes a good profit from sales
2	EM2		Product Cost per Unit	We keep the cost of making each handloom product low
3	EM3		Resource Consumption per Unit	We use yarn, dyes, and other materials efficiently for each product
4	EM4		Total Logistics Management Cost	Our costs for transporting materials, storage and production are reasonable

5	OM1	Operational measures	Supplier lead time	We often receive yarn, dyes, or other raw materials on the day promised by the supplier.
6	OM2		Equipment Utilization Ratio	Our looms and equipment are generally used effectively.
7	OM3		Capacity Utilization Rate (%)	We use our full production capacity well.
8	OM4		Employee Productivity (units/employee/day)	Each worker produces a good number of products daily.
9	OM5		Training frequency	We often receive necessary training or skill-updating sessions in the sector.
10	OM6		Production flexibility rating	We can easily change production based on customer orders
11	OM7		Inventory turnover ratio	Our finished products sell quickly without staying in stock long
12	OM8		Forecast accuracy rate	We accurately predict customer demand for our handloom products
13	OM9		Warehouse space utilization	We use our storage space efficiently
14	OM10		Defect rate in production	Very few of our handloom products have quality problems
15	OM11		Productivity ratio	We get good output from the resources we use
16	OM12		Waste and scrap percentage	We have minimal waste in yarn and other materials
17	OM13		Idle time (Non-productive time)	Our workers and machines have very little idle time
18	OM14		Employee turnover rate	Our skilled workers stay with us for long periods

19	CSM1	Customer satisfaction measures	Consumer complaints	We receive very few complaints from customers
20	CSM2		No of product range	We offer a good variety of handloom products
21	CSM3		Order Return Rate	Customers rarely return our products due to quality problems or not meeting expectations.
22	CSM4		On-time delivery rate	We deliver products to customers on the promised date
23	CSM5		New-product launch frequency (per year)	We regularly introduce new designs and patterns
24	CSM6		Responsiveness	We respond quickly to customer requests and inquiries