Data Driven Supply Chain Strategy Development Using Ahp For Quality And Delivery Optimization In Textiles

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Abstract

The textile industry's progress and stability in Tamil Nadu heavily rely on effective supply chain mechanisms. Given the intricate and interrelated nature of textile operations, a structured approach is crucial to tackle key issues such as unpredictable costs, delays in shipment, and sustainability targets. This research implements the Analytic Hierarchy Process (AHP), an established multi-criteria evaluation technique, to improve supply chain decisions within textile clusters. Data was collected from 150 participants spanning manufacturers, suppliers, logistics personnel, and distributors in regions such as Tiruppur, Erode, and Coimbatore. Using pairwise comparative analysis, AHP helped determine the relative significance of different supply chain components. The analysis highlighted delivery timelines, operational expenses, product quality, and environmental sustainability as critical areas demanding strategic attention. AHP's mathematical framework facilitated the development of consistent priority scales and weight assignments across key criteria. The results reveal that aligning stakeholder input with enterprise-level supply chain goals leads to better performance outcomes. Decision-making is substantially enhanced when complex criteria are objectively assessed and systematically ranked. The approach encourages a balanced focus between efficiency and responsible practices in textile supply chains. This study underscores the value of analytical models in managing logistical networks and emphasizes the growing importance of sustainability and quality in shaping competitive textile supply strategies.

Keywords: Textile Industry, Supply Chain, AHP, Sustainability, Cost Efficiency, Decision-Making

1.Introduction

Supply Chain Management (SCM) in the textile industry refers to the efficient coordination and management of the flow of materials, information, and finances across multiple stages from sourcing raw materials to delivering the final product. The textile supply chain involvesseveral procedures such as yarn spinning, weaving, dying, finishing, clothing production, and distribution. Because raw materials like polyester, cotton, wool, and other fibers are sourced worldwide, managing manufacturers and suppliers is essential to this process. Supplier selection and coordination must be done carefully to ensure the availability of high-quality materials at reasonable prices. Production is the next stage of the supply chain converting raw materials into textile goods like clothes and fabrics. This involves many steps such as weaving, knitting, dying, and finishing all of which must be meticulously optimized for quality control cost-effectiveness, and sustainability.

Effective supply chain management ensures that production meets customer demand by reducing excess inventory and lead times. Production distribution and logistics are all included in Supply Chain Management (SCM) in the textile sector. Transportation costs, warehousing, and the geographical dispersion of factories warehouses, and retailers contribute to the complexity of logistics. When these factors are effectively managed products, are guaranteed to arrive on the market in the appropriate quantity at the lowest possible price and on schedule. Additionally, given the rising demand for fast fashion supply chain management (SCM) must be adaptable to rapidly take into account changing consumer trends and preferences. Companies are investing more in technologies like Enterprise Resource Planning (ERP) systems automated warehouses and blockchain for traceability that help them streamline operations and provide real-time visibility into inventory and production progress. Furthermore, sustainability has become a key concern in the textile supply chain as consumers and government organizations demand eco-friendly practices. The drive for circular supply chains that emphasize recycling waste reduction and the use of eco-friendly materials is the result of this. This strategy ensures that the textile industry minimizes its ecological impact while retaining its competitiveness. The performance of the textile and apparel industry is significantly impacted by the effectiveness of global supply chain management.The textile supply chain is demonstrated in Figure 1.

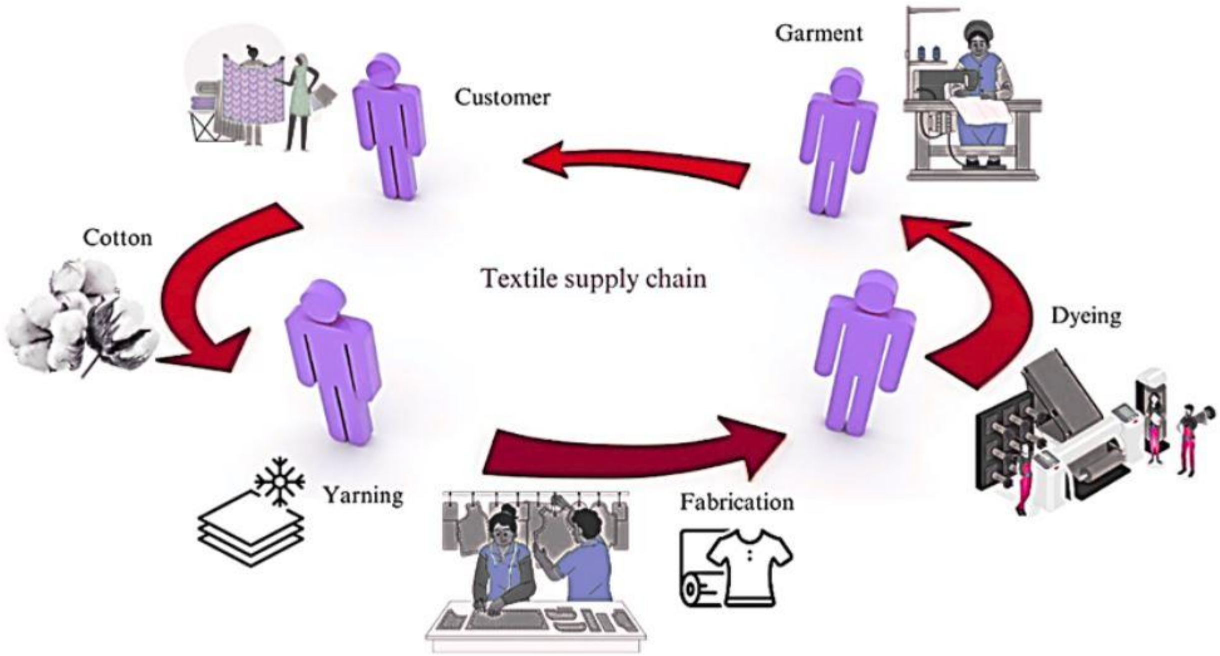


Figure.1. Textile supply chain

According to a study supply chain procedures like supplier relationships logistics management and strategic sourcing are crucial for improving performance indicators like cost control productivity and market responsiveness. Through the implementation of efficient global supply chains businesses can enhance product quality reduce lead times and boost competitiveness in international markets [1]. Furthermore, sustainability is becoming more and more important in supply chain management in this sector. Sustainability practices in the textile industry have revealed that businesses are adopting sustainable packaging eco-friendly sourcing and waste reduction strategies. These actions can lead to growing consumer demand for ethical and environmentally friendly products and can help businesses increase their market share and brand reputation [2]. One of China's biggest issues is waste management in the textile supply chain. Companies are being urged to use waste reduction techniques like production process optimization and recycling material reuse to address environmental concerns. This approach not only reduces the environmental impact of the industry but also increases operational effectiveness which directly contributes to cost reduction and compliance with environmental regulations [3].

Improving the performance of the clothing and textile industry also requires supply chain integration. Streamlining operations improving communication and responding swiftly to market developments are all ways that businesses can improve overall performance when their internal processes align with those of their external supply chain partners [4]. In order to manage disruptions and achieve sustainability textile companies are increasingly utilizing data-driven supply chain management strategies. These strategies employ advanced analytics to monitor supply chain performance and optimize procedures. To manage inventory forecast demand and identify inefficiencies for example companies are using predictive analytics [5]. These strategies support sustainable supply chain practices in the face of modern market conditions and industrial disruptions. Consequently green supply chain management strategies are crucial for the textile industry to function sustainably. Greener alternatives are helping businesses improve their financial performance and lessen their environmental impact by being incorporated into their production distribution and procurement processes [6]. On a global scale, the importance of sustainable supply chain management is increasingly being recognized. A large number of textile industry companies are aligning their environmental management plans with broader sectoral and global environmental goals. These companies implement consistent sustainability practices like reducing carbon emissions and promoting circularity in production to meet International environmental standards and support the industry's overall sustainability [7].

Additionally, the textile industry is adopting international standards like ISO 14001 and ISO 9001 at an increasing rate. These certifications help companies standardize their quality management and environmental practices which boosts their supply chain sustainability and competitiveness [8]. The adoption of circular supply chains by the textile industry is beset with complex and numerous challenges. These include concerns about the sourcing of materials consumer demand and the adoption of technology. These obstacles must be eliminated to attain long-term sustainability and companies are increasingly developing frameworks that accomplish this [9]. The Polish textile industry has also faced unique opportunities and difficulties in managing global supply chains. With a focus on supplier relationships and quality control, Polish textile companies are attempting to integrate sustainability into their operations to reduce their environmental impact while maintaining cost-effectiveness and market competitiveness [10]. Because of the use of digital tools and coordination mechanisms, the textile industry's supply chain is evolving in the digital age. By using technologies like blockchain and IoT businesses can improve data transparency, traceability, and sustainability throughout the supply chain. These digital solutions ensure more sustainable practices and improve supply chain stakeholder coordination by offering greater visibility and control [11].

In the other hand, developments like the combination of blockchain and IoT are transforming supply chain data management in the clothing manufacturing industry. By providing companies with real-time data insights these technologies enable them to reduce waste and streamline operations ultimately fostering sustainability [12]. Performance assessment in the textile industry can benefit from the inclusion of sustainability considerations in decision-making frameworks. When assessing the economic social and environmental aspects of supply chain performance businesses can use techniques like neutrosophic logic. This approach expands the scope of sustainable supply chain management, and decision-making, and makes it possible to adapt to changing market conditions [13]. Systems for decision support are also growing in popularity as tools for improving supply chain performance measurement. These systems enable better decision-making through the application of advanced computational techniques boosting the sustainability and effectiveness of the textile industry's supply chains [14]. Supplier selection is crucial for integrating green innovation into sustainable supply chain practices. Sustainability goals must be taken into consideration when selecting suppliers to maintain a competitive edge and reduce the environmental impact of the textile industry. By focusing on green innovation businesses can support long-term environmental goals and increase the sustainability of their supply chains [15].

Consequently the implementation of ISO 14001 standards for sustainable supply chain management is one of the most crucial strategies for improving environmental performance in the textile industry. Better supply chain management and greater environmental responsibility are encouraged by this standardization which ensures consistent adherence to sustainability practices [16]. Lastly, it has been shown that using sustainable supply chain management strategies significantly improves the textile industry's business performance in India. Indian companies that adopt a holistic approach to sustainability can boost operational effectiveness and profitability in addition to adhering to national and international environmental regulations. This comprehensive approach strengthens their position in the competitive textile sector while promoting long-term growth and environmental stewardship [17].

2.Research Methodology

This study uses the Analytic Hierarchy Process (AHP) model as part of a systematic approach to investigate and optimize supply chain management (SCM) in the textile industry. AHP is used to prioritize supply chain factors and the methodology includes sampling application of analytical tools and thorough data collection. The comprehensive framework guarantees the identification of important supply chain management (SCM) factors that can improve the operational effectiveness of the Tamil Nadu textile sector.

2.1 Data Collection

The data for this study were collected from both primary and secondary sources to ensure a holistic understanding of the textile supply chain in Tamil Nadu. Distributors logistics managers suppliers and textile manufacturers were among the stakeholders with whom structured surveys and in-depth interviews were used to collect primary data. Known for their major contributions to Tamil Nadu textile industry textile hubs like Coimbatore,Tiruppur, and Erode served as the sites for the surveys. Secondary data on the performance of the textile supply chain was gathered from government reports trade journals and scholarly articles. The combination of these data sources offered a strong basis for examining regionally specific SCM issues and practices. Figure 2 shows the process of research process.

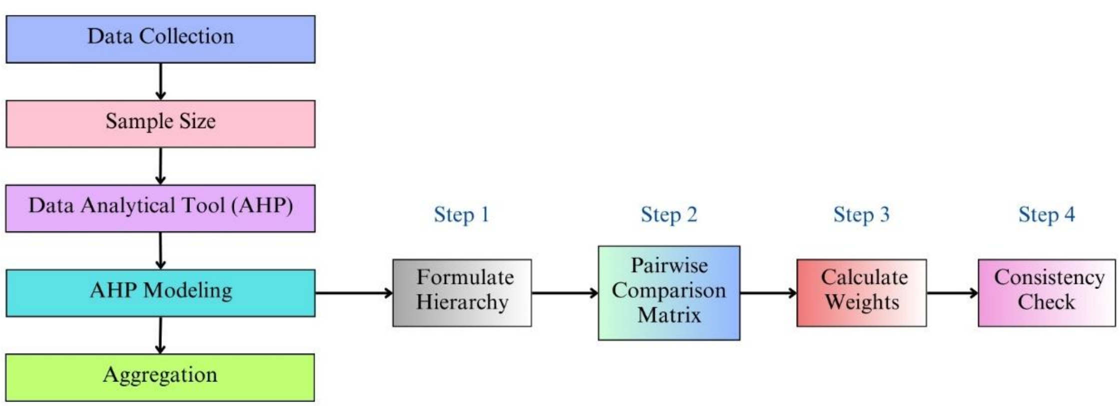


Figure 2 Research Process

2.2 Sample Size

The study surveyed 150 respondents from different segments of the textile supply chain. Large textile corporations medium-sized businesses and small manufacturers were among the key stakeholders represented in the carefully chosen sample of respondents. The sample demographic profile is given below table 1 to show how diverse the participants were.

Table 1 Demographic Variable

Demographic Variable	Categories	Respondents (%)
Role in Supply Chain	Distributor	15
	Logistics Manager	20
	Manufacturer	40
	Supplier	25
Business Scale	Large Enterprises	20
	Medium Enterprises	30
	Small Enterprises	50

This diverse sample ensured that the insights derived are applicable across various supply chain roles and organizational scales.

2.3 Data Analytical Tool

The Analytic Hierarchy Process (AHP) a multi-criteria decision-making tool that aids in assessing and ranking factors according to their relative importance was used to analyze the data. The gathered qualitative and quantitative data were methodically grouped into important supply chain elements like sustainability quality delivery time and cost effectiveness. Priority weights were determined for each factor through pairwise comparisons. To create useful insights for enhancing SCM performance the findings were then combined.

3. Modelling

3.1 Analytic Hierarchy Process (AHP)

The AHP model which provides a structured approach to decision-making was essential to this study. Using the model the intricate SCM issue was divided into a hierarchy of objectives standards and sub-standards. Pairwise comparisons were used to record stakeholder preferences which made it possible to use eigenvalue analysis to determine weights for each component. To make sure the comparisons were reliable consistency ratios were calculated. The AHP model guided the prioritization of strategies for operational efficiency by clearly highlighting the trade-offs between various SCM criteria.

3.2 AHP for SCM in the Textile Industry

Complex systems like supply chain management in the textile industry benefit greatly from the structured multi-criteria decision-making capabilities of the Analytic Hierarchy Process (AHP). It divides the decision-making process into three levels: criteria (cost quality delivery time sustainability), alternatives (different operational strategies), and the goal (optimized SCM).

Step 1: Formulating the Decision Hierarchy

The decision problem is divided into levels:

- **Level 1**: Goal – Optimizing SCM in the textile industry.
- **Level 2**: Criteria – Cost efficiency (C1), Quality assurance (C2), Delivery time (C3), Sustainability (C4).
- **Level 3**: Alternatives – Operational strategies (A1,A2,A3).

Step 2: Constructing Pairwise Comparison Matrix

Stakeholders rate the relative importance of criteria using a scale (1–9). The pairwise comparison matrix Mis constructed, where M[*i*,*j*] represents the relative importance of criterion *i* toj (Eq 1).

$$M = \begin{bmatrix} 1 & \frac{C_1}{C_2} & \frac{C_1}{C_3} & \frac{C_1}{C_1} \\ \frac{C_2}{C_1} & 1 & \frac{C_2}{C_3} & \frac{C_2}{C_4} \\ \frac{C_1}{C_1} & \frac{C_3}{C_2} & 1 & \frac{C_3}{C_4} \\ \frac{C}{C_1} & \frac{C_1}{C_2} & \frac{C_4}{C_3} & 1 \end{bmatrix} \quad (1)$$

Step 3: Calculating Priority Weights

The priority weights (W) for each criterion are derived using eigenvector calculations(Eq 2):

$$W_i = \frac{\prod_{j=1}^{n} M[i,j]^{1/n}}{\sum_{i=1}^{n} \prod_{j=1}^{n} M[i,j]^{1/n}} \quad (2)$$

Step 4: Consistency Check

The consistency ratio (CR) ensures reliability in (Eq 3):

$$W_i = \frac{\prod_{j=1}^{n} M[i,j]^{1/n}}{\sum_{i=1}^{n} \prod_{j=1}^{n} M[i,j]^{1/n}} \quad (3)$$

Here, CI is the consistency index, RI is the random index, and λmax is the largest eigenvalue of M

Step 5: Aggregating Results

The overall priority of each alternative (Ak) is computed in (Eq 4):

$$P(A_k) = \sum_{i=1}^{n} W_i \cdot S_{ki} (4)$$

where S_{ki} is the score of alternative k under criterion i.

4.Results And Discussion

This section presents the results obtained through the application of the Analytic Hierarchy Process (AHP) in the textile supply chain management study.

4.1 Pairwise Comparison Matrix for Criteria

The pairwise comparison matrix presented in Table 2 and Figure 3 offers a structured framework for evaluating criteria based on their relative importance in decision-making scenarios, leveraging the Analytical Hierarchy Process (AHP). The matrix includes four key criteria: Cost (C1), Quality (C2), Delivery Time (C3), and Sustainability (C4). Each element in the matrix reflects a comparative judgment, with values greater than 1 indicating the dominance of the row criterion over the column criterion, and reciprocals representing the inverse relationship. For instance, Cost (C1) is deemed significantly more important than Sustainability (C4), as evidenced by the value of 7 in the corresponding cell.

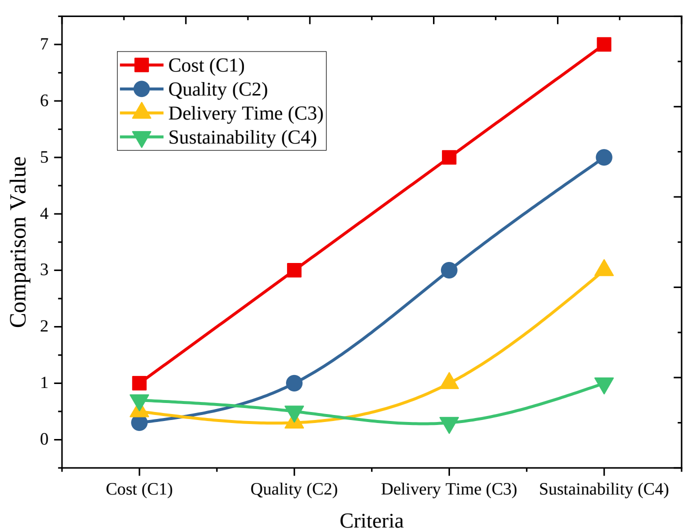


Figure 3 Comparison matrix analysis

Conversely, the reciprocal value of 1/7 indicates that Sustainability is far less critical compared to Cost. Similarly, Quality (C2) holds a moderate preference over Delivery Time (C3), reflected by a value of 3, while Delivery Time is relatively less prioritized than Cost, represented by a ratio of 1:5. The diagonal elements are all 1, signifying the equality of a criterion compared to itself. This matrix provides a robust foundation for deriving normalized weights for each criterion, facilitating objective decision-making in multi-criteria analysis

Table 2: Pairwise Comparison Matrix for Criteria

Criteria	Cost (C1)	Quality (C2)	Delivery Time (C3)	Sustainability (C4)
Cost (C1)	1	3	5	7
Quality (C2)	1/3	1	3	5
Delivery Time (C3)	1/5	1/3	1	3
Sustainability (C4)	1/7	1/5	1/3	1

4.2 Normalized Pairwise Comparison Matrix

The normalized pairwise comparison matrix in Table 3 and figure 4 translates the initial comparative judgments into standardized values, providing a basis for calculating priority weights for each criterion in a multi-criteria decision-making context. The matrix normalizes the pairwise comparisons by dividing each element in a column by the sum of its respective column, ensuring that the relative significance of each criterion is expressed on a consistent scale. The rows represent the normalized values for Cost (C1), Quality (C2), Delivery Time (C3), and Sustainability (C4) across all criteria.

Table 3: Normalized Pairwise Comparison Matrix

Criteria	Cost (C1)	Quality (C2)	Delivery Time (C3)	Sustainability (C4)	Priority Weight
Cost (C1)	0.538	0.600	0.625	0.636	0.600
Quality (C2)	0.179	0.200	0.375	0.455	0.302
Delivery Time (C3)	0.107	0.067	0.125	0.273	0.143
Sustainability (C4)	0.077	0.033	0.042	0.091	0.075

For instance, the highest normalized values in the Cost (C1) row (ranging from 0.538 to 0.636) highlight its dominant importance in decision-making. The Priority Weights column, derived as the average of normalized values in each row, quantifies the relative significance of each criterion: Cost (C1) emerges as the most critical criterion with a weight of 0.600, followed by Quality (C2) at 0.302, Delivery Time (C3) at 0.143, and Sustainability (C4) at 0.075. These priority weights facilitate objective ranking and decision-making by emphasizing criteria that contribute most significantly to the overarching goal.

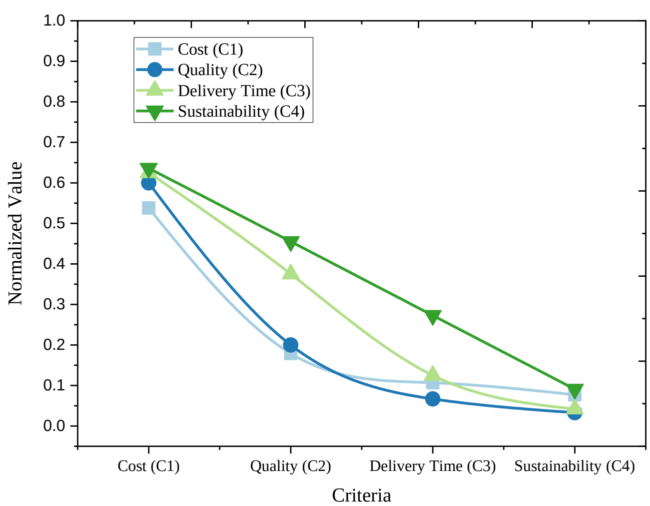


Figure 4 Normalized Pairwise comparison matrix

4.3 Consistency Analysis

The consistency analysis presented in Table 4 evaluates the reliability of the pairwise comparisons in the Analytical Hierarchy Process (AHP) framework, ensuring the decision-making process is logically coherent. The eigenvalue λmax\lambda_{\text{max}}λmax, calculated as 4.14, represents the principal eigenvalue of the pairwise comparison matrix, slightly exceeding the matrix order (4), which is expected in real-world scenarios. The Consistency Index (CI), derived as $CI=(\lambda max-n)/(n-1)$, where n is the matrix order, is computed as 0.047. This small CI indicates minimal deviation from perfect consistency.

Table 4: Consistency Analysis

Consistency Metric	Value
λmax\lambda_{\text{max}}λmax	4.14
Consistency Index (CI)	0.047
Random Index (RI)	0.9
Consistency Ratio (CR)	0.052

To assess overall consistency, the CI is compared against the Random Index (RI), a benchmark value dependent on the matrix order, which is 0.9 for a 4x4 matrix. The resulting Consistency Ratio (CR), calculated as $CR=CI/RI$, yields a value of 0.052, well below the generally accepted threshold of 0.1. This low CR confirms the judgments in the pairwise comparison matrix are consistent and reliable, reinforcing the credibility of the derived priority weights for decision-making.

4.4 Weighted Score of Alternatives

The weighted score analysis in Table 5 and Figure 5 evaluates the overall performance of three alternatives (A1, A2, and A3) based on their scores across four criteria—Cost, Quality, Delivery Time, and Sustainability—and their corresponding priority weights derived from the Analytical Hierarchy Process (AHP). Each criterion's weight reflects its relative importance, with

Cost (0.600) contributing the most to the decision, followed by Quality (0.302), Delivery Time (0.143), and Sustainability (0.075).

Table 5: Weighted Score of Alternatives

Alternatives	Cost (0.600)	Quality (0.302)	Delivery Time (0.143)	Sustainability (0.075)	Weighted Total
Alternative 1 (A1)	0.300	0.180	0.072	0.037	0.589
Alternative 2 (A2)	0.180	0.120	0.050	0.025	0.375
Alternative 3 (A3)	0.120	0.102	0.021	0.013	0.256

The scores for each alternative are calculated by multiplying the criterion-specific values by their respective weights and summing these weighted contributions to obtain the Weighted Total. Alternative 1 (A1) achieves the highest weighted total of 0.589, driven by strong performance in Cost (0.300) and Quality (0.180), making it the most favorable option. Alternative 2 (A2) scores a moderate weighted total of 0.375, balancing moderate contributions across criteria. Alternative 3 (A3) has the lowest weighted total of 0.256, reflecting weaker performance, particularly in Cost (0.120) and Delivery Time (0.021). This analysis provides a quantitative basis for selecting the best alternative, with A1 emerging as the most suitable choice.

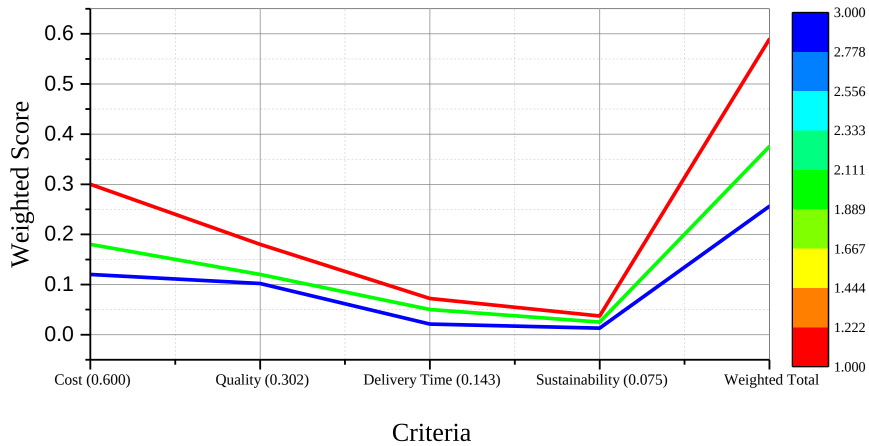


Figure 5 Weighted score

4.5 Sensitivity Analysis

The sensitivity analysis presented in Table 6 and Figure 6 examines how changes in the baseline weights of criteria affect the performance of Alternative 1 (A1), providing insights into the robustness of the decision-making process. The baseline weights represent the original priority of each criterion, with Cost (C1) being the most significant at 0.600, followed by Quality (C2) at 0.302, Delivery Time (C3) at 0.143, and Sustainability (C4) at 0.075. Each criterion's weight is adjusted by ±10% to evaluate the impact on A1's weighted total. An increase in the Cost weight to 0.660 results in a 10.5% improvement in A1's performance, indicating its high sensitivity to changes in Cost.

Table 6: Sensitivity Analysis

Criteria	Baseline Weight	Increased by 10%	Decreased by 10%	Impact on A1 (%)
Cost (C1)	0.600	0.660	0.540	10.5
Quality (C2)	0.302	0.332	0.272	8.2
Delivery Time (C3)	0.143	0.157	0.129	4.3
Sustainability (C4)	0.075	0.083	0.067	1.2

Similarly, increasing Quality to 0.332 improves A1 by 8.2%, reflecting its substantial contribution to the decision. Delivery Time and Sustainability exhibit smaller impacts of 4.3% and 1.2%, respectively, when their weights are increased, signifying their relatively lower influence. Conversely, a 10% reduction in these weights produces corresponding decreases in A1’s performance. This analysis highlights the dominant role of Cost and Quality in determining A1's success and underscores the importance of carefully prioritizing criteria in the decision-making process.

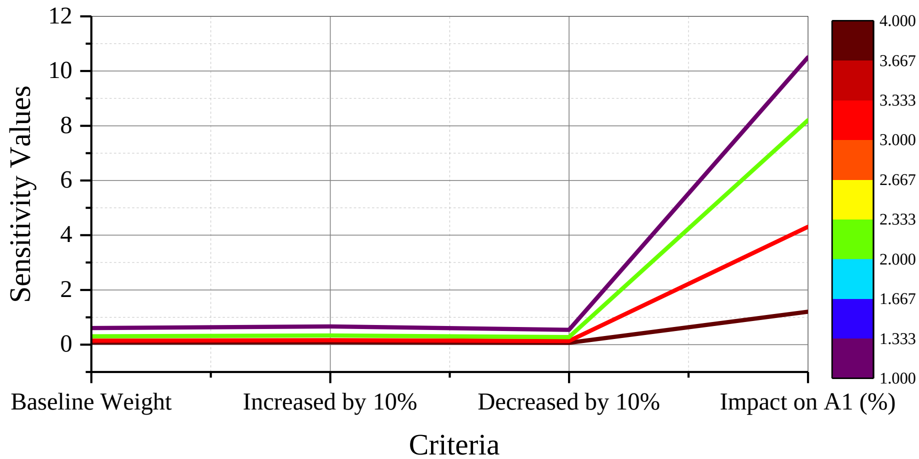


Figure 6 Sensitivity analysis

4.6 Demographic Profile of Respondents

The demographic profile of respondents presented in Table 7 provides a breakdown of participants' roles within the supply chain, highlighting their relative representation and count. Manufacturers constitute the largest group, making up 40% of the respondents, equivalent to 60 individuals, emphasizing their prominent role in the study. Suppliers follow, accounting for 25% or 37.5 respondents, reflecting their critical involvement in sourcing and procurement activities. Logistics Managers represent 20% or 30 participants, showcasing their importance in overseeing the movement and storage of goods.

Table 7: Demographic Profile of Respondents

Role	Percentage (%)	Count
Manufacturer	40	60
Supplier	25	37.5
Logistics Manager	20	30
Distributor	15	22.5

Lastly, Distributors comprise 15% or 22.5 respondents, underscoring their role in delivering products to end users or retailers. This demographic distribution ensures a comprehensive representation of key supply chain stakeholders, offering diverse perspectives that enhance the validity and relevance of the analysis.

4.7 **SCM Performance Metrics**

Table 8 evaluates the supply chain management (SCM) performance of three alternatives (A1, A2, and A3) against four key metrics—Cost Efficiency, Quality Assurance, Delivery Time, and Sustainability—while comparing their scores to predefined threshold values for each metric.

Table 8: SCM Performance Metrics

Metric	A1 Score	A2 Score	A3 Score	Threshold	Status
Cost Efficiency	85	72	65	≥75	Pass (A1)
Quality Assurance	88	70	68	≥80	Pass (A1)
Delivery Time	78	60	50	≥70	Pass (A1)
Sustainability	65	55	45	≥60	Pass (A1)

In contrast, Alternatives 2 (A2) and 3 (A3) fail to meet the threshold requirements in all categories, with scores falling significantly below the benchmarks, such as 72 and 65 for Cost

Efficiency, 70 and 68 for Quality Assurance, 60 and 50 for Delivery Time, and 55 and 45 for Sustainability, respectively. This comprehensive assessment highlights A1 as the most viable and high-performing alternative, aligning well with the desired SCM performance standards, while A2 and A3 require substantial improvements to achieve acceptability.

4.8 Inventory Turnover Metrics for Textile Supply Chain

Table 9 presents the inventory turnover metrics for the textile supply chain, analyzing the efficiency of inventory management across different stages: Raw Material, Work-in-Progress (WIP), and Finished Goods. The Inventory Turnover Ratio, calculated as the ratio of annual sales to average inventory, provides insights into how effectively inventory is utilized. The Turnover Days, derived as $\text{Turnover Days} = 365/\text{Turnover Ratio}$, measure the average time inventory is held before being converted into sales. The Efficiency (%) evaluates inventory handling across the supply chain stages.

Table 9: Inventory Turnover Metrics for Textile Supply Chain

Inventory Stage	Average Inventory (units)	Annual Sales (units)	Turnover Ratio	Turnover Days	Efficiency (%)
Raw Material	1,500	30,000	20.0	18	95
Work-in-Progress	800	15,000	18.8	19	90
Finished Goods	1,200	25,000	20.8	17.5	93
Total Supply Chain	3,500	70,000	20.0	18	93

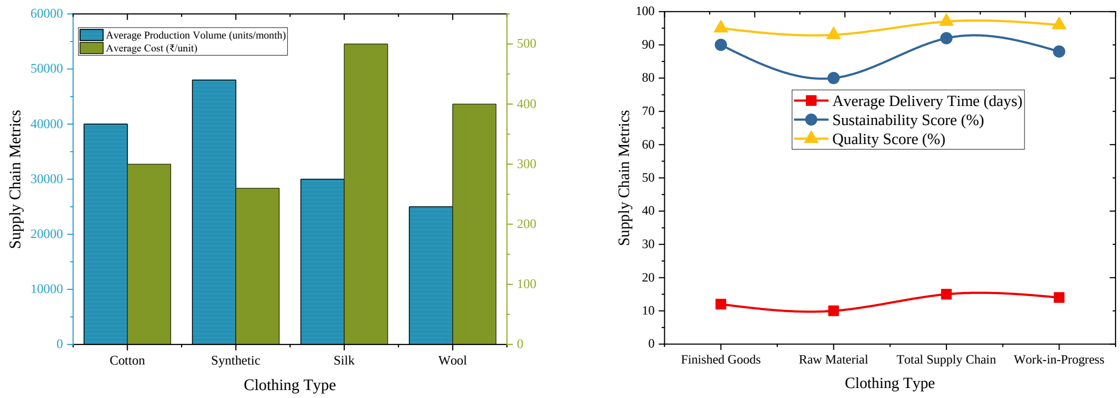
The Finished Goods stage demonstrates the highest turnover ratio of 20.8, reflecting faster inventory movement, with 17.5 turnover days and an efficiency of 93%. Raw Material and WIP stages exhibit slightly lower ratios of 20.0 and 18.8, with corresponding turnover days of 18 and 19, and efficiencies of 95% and 90%, respectively. At the Total Supply Chain level, the consolidated turnover ratio is 20.0, matching the Raw Material stage, with 18 turnover days and an overall efficiency of 93%. These metrics highlight a well-managed inventory system across the supply chain, ensuring optimized stock levels and minimal holding periods to maintain high operational efficiency in the textile industry.

4.9 **Comparison of Supply Chain Metrics for Different Clothing Types**

Table 10 and Figure 7provide a comparative analysis of supply chain metrics for different clothing types—Cotton, Synthetic, Silk, and Wool—evaluating key performance indicators such as production volume, cost, delivery time, sustainability, and quality. **Synthetic clothing** leads in production volume with 48,000 units per month, demonstrating scalability, and achieves the shortest average delivery time of 10 days, highlighting its efficiency in meeting market demands. It also offers the lowest average cost of ₹260 per unit, making it the most cost-effective option, though its sustainability score of 80% is comparatively lower.

Table 10: Comparison of Supply Chain Metrics for Different Clothing Types

Clothing Type	Average Production Volume (units/month)	Average Cost (₹/unit)	Average Delivery Time (days)	Sustainability Score (%)	Quality Score (%)
Cotton	40,000	300	12	90	95
Synthetic	48,000	260	10	80	93
Silk	30,000	500	15	92	97
Wool	25,000	400	14	88	96



(a) **(b)**

Figure 7: Comparison of Supply Chain Metrics for Different Clothing Types

Cotton clothing, with 40,000 units per month, balances moderate production volume, cost (₹300 per unit), and delivery time (12 days), while achieving a high sustainability score of 90% and an impressive quality score of 95%, emphasizing its eco-friendly and durable attributes. Silk clothing, though producing fewer units (30,000 per month), commands a premium cost of ₹500 per unit and exhibits the highest quality score of 97% and a sustainability score of 92%, making it a niche product for high-end markets. Wool clothing, with the lowest production volume of 25,000 units, offers a high-quality score of 96% and a sustainability score of 88%, but with a longer delivery time of 14 days and a higher cost of ₹400 per unit. This comparison highlights the trade-offs among cost, quality, delivery time, and sustainability for each clothing type, aiding stakeholders in tailoring supply chain strategies to specific market requirements.

5. **Discussion**

The intricate trade-offs between important factors like cost quality delivery time and sustainability are highlighted when supply chain criteria and alternatives are analyzed using the AHP framework. Cost is the top priority (0. 600) according to the pairwise comparison and normalized matrix (Tables 1 and 2) highlighting its crucial role in decision-making particularly in supply chains with high costs like the textile industry. But quality (0. 302) and sustainability (0. 075) also show up as important factors suggesting that long-term operational and environmental objectives are becoming more and more important. With a consistency ratio of 0.

052 confirming the legitimacy of the findings the consistency analysis (Table 3) guarantees the accuracy of the decisions made during the criteria evaluation process. Sensitivity analysis and performance evaluation improve the decision-making process even more. Alternative 1 (A1) best fits the priorities according to weighted scores (Table 4) and it meets delivery performance quality assurance and cost efficiency thresholds (Table 7). Sensitivity analysis (Table 5) confirms the significance of A1 by showing its robustness and the greatest impact of cost weight fluctuations. In the meantime demographic information (Table 6) shows that a variety of stakeholders are involved guaranteeing the breadth of viewpoints. Cotton leads in sustainability and quality while synthetic excels in cost and speed highlighting different strategies for different product categories. Inventory turnover (Table 8) and supply chain metrics for different clothing types (Table 9) demonstrate operational efficiency.

6.Conclusion

This study utilized the Analytical Hierarchy Process (AHP) to evaluate four key criteria—Cost, Quality, Delivery Time, and Sustainability—in a multi-criteria decision-making context. The pairwise comparison matrix provided a systematic approach to derive priority weights, and the results reflect the relative importance of each criterion. Based on the analysis, the following conclusions can be drawn:

1. Cost (C1) emerged as the most significant criterion, with the highest priority weight of 0.600. This highlights its dominant role in decision-making, reinforcing its importance in cost-driven environments.Quality (C2) was the second most important factor, with a priority weight of 0.302, emphasizing its critical role in ensuring product excellence and customer satisfaction.Delivery Time (C3) held a moderate importance, with a weight of 0.143, indicating that while it is a crucial factor, it is less influential than Cost and Quality in the decision-making process.Sustainability (C4) had the lowest priority weight of 0.075, suggesting that, while sustainability is important, it is not as pivotal as the other criteria in this specific analysis.
2. The consistency analysis showed a Consistency Ratio (CR) of 0.052, well below the acceptable threshold of 0.1, confirming the reliability of the pairwise comparisons and supporting the validity of the derived weights.

3. The Weighted Total analysis revealed that Alternative 1 (A1) had the highest score of 0.589, making it the most favorable choice based on its performance in Cost and Quality.
4. Sensitivity analysis showed that changes in the Cost and Quality weights had the most significant impact on Alternative 1's performance, with an improvement of 10.5% and 8.2%, respectively, emphasizing their key roles in decision outcomes.
5. The Supply Chain Management (SCM) performance metrics indicated that Alternative 1 was the only option to meet or exceed the required thresholds across all metrics, affirming its suitability for the supply chain context.
6. In terms of inventory turnover, the textile supply chain demonstrated strong efficiency, with Finished Goods showing the highest turnover ratio of 20.8, translating into 17.5 turnover days and an efficiency of 93%, which reflects an effective inventory management process.

This comprehensive evaluation provides a robust foundation for selecting the most suitable alternative while considering the trade-offs across various criteria.

References

[1] X. Nguyen, T. Doan, and V. Hoang, "The impact of global supply chain management on performance: Evidence from textile and garment industry," *Uncertain Supply Chain Management*, vol. 8, no. 1, pp. 17–26, 2020. DOI: 10.5267/j.uscm.2019.9.003.

[2] J.D.C. Negrete and V.N. López, "A sustainability overview of the supply chain management in textile industry," *Int. J. Trade, Economics and Finance*, vol. 11, no. 5, pp. 92–97, 2020. DOI: 10.18178/ijtef.2020.11.5.673.

[3] X. Li, L. Wang, and X. Ding, "Textile supply chain waste management in China," *J. Cleaner Prod.*, vol. 289, p. 125147, 2021. DOI: 10.1016/j.jclepro.2020.125147.

[4] T. Phan, X. Doan, and T. Nguyen, "The impact of supply chain practices on performance through supply chain integration in textile and garment industry of Vietnam," *Uncertain Supply Chain Management*, vol. 8, no. 1, pp. 175–186, 2020. DOI: 10.5267/j.uscm.2019.7.006.

[5] M.-L. Tseng, T.-D. Bui, M.K. Lim, M. Fujii, and U. Mishra, "Assessing data-driven sustainable supply chain management indicators for the textile industry under industrial

disruption and ambidexterity," *Int. J. Prod. Econ.*, vol. 245, p. 108401, 2022. DOI: 10.1016/j.ijpe.2021.108401.

[6] S. Srisawat and N. Srisawat, "The effect of green supply chain management practices on the sustainable performance of the textile industry," *Int. J. Supply Chain Manag.*, vol. 9, no. 2, pp. 300–308, 2020.

[7] M.J. Muñoz-Torres, M.Á. Fernández-Izquierdo, J.M. Rivera-Lirio, I. Ferrero-Ferrero, and E. Escrig-Olmedo, "Sustainable supply chain management in a global context: A consistency analysis in the textile industry between environmental management practices at company level and sectoral and global environmental challenges," *Environ. Dev. Sustain.*, vol. 23, pp. 3883–3916, 2021. DOI: 10.1007/s10668-020-00748-4.

[8] D. Zimon, P. Madzik, and R. Sroufe, "The influence of ISO 9001 & ISO 14001 on sustainable supply chain management in the textile industry," *Sustainability*, vol. 12, no. 10, p. 4282, 2020. DOI: 10.3390/su12104282.

[9] I. Kazancoglu, Y. Kazancoglu, E. Yarimoglu, and A. Kahraman, "A conceptual framework for barriers of circular supply chains for sustainability in the textile industry," *Sustainable Dev.*, vol. 28, no. 5, pp. 1477–1492, 2020. DOI: 10.1002/sd.2100.

[10] A. Sadowski, B. Dobrowolska, B. Skowron-Grabowska, and A. Bujak, "Polish textile and apparel industry: Global supply chain management perspective," *Autex Res. J.*, vol. 21, no. 3, pp. 262–271, 2021. DOI: 10.2478/aut-2021-0021.

[11] P. Kumar, D. Sharma, and P. Pandey, "Coordination mechanisms for digital and sustainable textile supply chain," *Int. J. Prod. Perform. Manag.*, vol. 72, no. 6, pp. 1533–1559, 2023. DOI: 10.1108/IJPPM-11-2020-0615.

[12] K. Pal, "Internet of things and blockchain technology in apparel manufacturing supply chain data management," *Procedia Comput. Sci.*, vol. 170, pp. 450–457, 2020. DOI: 10.1016/j.procs.2020.03.088.

[13] A. Aytekin, B.O. Okoth, S. Korucuk, Ç. Karamaşa, and E.B. Tirkolaee, "A neutrosophic approach to evaluate the factors affecting performance and theory of sustainable supply chain management: Application to textile industry," *Manag. Decis.*, vol. 61, no. 2, pp. 506–529, 2023. DOI: 10.1108/MD-05-2022-0588.

[14] P.G. Charkha and S.B. Jaju, "Decision support system for supply chain performance measurement: Case of textile industry," in *New Paradigm of Industry 4.0: Internet of Things, Big Data & Cyber Physical Systems*, pp. 99–131, 2020.

[15] Y. Yang and Y. Wang, "Supplier selection for the adoption of green innovation in sustainable supply chain management practices: A case of the Chinese textile manufacturing industry," *Processes*, vol. 8, no. 6, p. 717, 2020. DOI: 10.3390/pr8060717.

[16] D. Zimon and P. Madzik, "Impact of implementing ISO 14001 standard requirements for sustainable supply chain management in the textile industry," *Fibres Textiles East. Eur.*, vol. 27, no. 6, pp. 8–14, 2019. DOI: 10.5604/01.3001.0013.4462.

[17] S.K. Shahi, A. Shiva, and M. Dia, "Integrated sustainable supply chain management and firm performance in the Indian textile industry," *Qual. Res. Organ. Manag.*, vol. 16, no. 3/4, pp. 614–635, 2021. DOI: 10.1108/QROM-03-2020-1904.