OPEN ACCESS

Volume: 13

Special Issue: 1

Month: May

Year: 2026

P-ISSN: 2321-4643

E-ISSN: 2581-9402

Citation:
Manjith, M., and M. Adlin. "Supply Chain Management System In Manufacturing Industry – A Special Reference to Keltron Corporation Ltd, Karakulam." *Shanlax International Journal of Management*, vol. 13, no. S1, 2026, pp. 128–136.

DOI:
https://doi.org/10.34293/management.v13iS1-i2-may.10986

Supply Chain Management System In Manufacturing Industry – A Special Reference to Keltron Corporation Ltd, Karakulam

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Abstract

Supply Chain Management (SCM) is a crucial factor to enhance the operational efficiency of the business, minimize delay, inventory control, and facilitate smooth coordination between procurement, production, warehousing and distribution. The present study analyses the Supply Chain Management system followed in KELTRON Equipment Complex, Karakulam, Kerala. The study primarily deals with the procurement and supplier relationship management, inventory management and warehousing and production planning and distribution of the company. Secondary data was gathered from company records, journals, reports and organizational documents. Evaluation was done using various analytical tools such as Value Stream Mapping (VSM), Pareto Analysis, Supplier Performance Scorecard, Lead Time Analysis, ABC Inventory Analysis, Economic Order Quantity (EOQ), Cycle Time Analysis and Bottleneck Analysis. The research revealed that the main operational challenges were delays in procurement, problems of reliability of suppliers, inefficiency in inventory management, production bottlenecks etc. EOQ and ABC analysis helped to plan inventory efficiently and bottleneck analysis revealed that PCB Assembly is the critical bottleneck for production. The research finally states that better coordination of suppliers, automation systems, lean scheduling, and technology-driven inventory management systems can make a significant impact on operational effectiveness and supply chain performance.

Keywords: Bottleneck Analysis, EOQ, Inventory Management, Procurement, Production Planning Supply Chain Management.

Introduction

Supply Chain Management is defined as the integration and coordination of procurement, production, inventory management, warehouse, transportation and distribution activities to ensure the smooth flow of materials and information in the organization. With effective SCM, productivity is increased, the operation's cost is lowered, the delay is decreased, and customer satisfaction is increased.

Competition, technology and customer expectations are impacting manufacturing industries in new and growing ways. Public sector organizations particularly find themselves suffering from inefficiency in the operations due to delays in procurement, excess inventory, logistical problems and production bottlenecks. Hence, the importance of efficient supply chain management for the operational stability and competitiveness is crucial. KELTRON Equipment Complex is one of the premier electronics manufacturing units in public sector under the Government of Kerala. Organisation produces high-end electronics products, power products, surveillance systems, PCB components and strategic electronic products for various government departments like ISRO, Indian Navy and ONGC. This study emphasizes the analysis of the effectiveness of procurement, supplier relationship management practices, inventory management and warehouse efficiency, and production planning and distribution strategies used at KELTRON.

Review of Literature

Zihe Ma (2025) analysed the evolution of supply chain management systems from traditional ERP systems to intelligent cloud-based ecosystems integrated with IoT, AI, and Big Data analytics. The study found that Digitization enhances operational agility and forecasting efficiency. The study conducted by Umari Abdurrahim Abi Anwar et al. (2025) was aimed at analyzing the effect of Supply Chain Integration (SCI) on business performance of companies in Indonesia.

The study determined that internal integration, supplier integration and customer integration has a positive effect on operational and financial performance. Supplier integration was the most critical element to cost reduction and efficiency. A solution of customer integration enabled the firms to react rapidly to the market needs by means of digital tools feedback systems. The study by Karishma M. Qureshi et al. (2024) investigates the impact of Industry 4.0 technologies on enhancing sustainable manufacturing supply chain performance. The authors used the Partial Least Squares Structural Equation Modeling approach to analyze the relationship between technology utilization and process innovation. It was concluded that the Internet of Things, automation, and big data analytics are useful technologies to increase the operational efficiency and sustainability. Xiaofei Liu, Xin Wang, Zixuan Wu and Mingxuan Xie (2024) studied the problems and potentials of global supply chains. The study underscored the fact that geopolitical tensions, the China-US trade conflict and the COVID-19 pandemic have revealed the vulnerabilities of supply chains, and made a call for agility and diversification. According to Masroor Alam (2022), some of the best practices in supply chain management in manufacturing industries are customer relationship management and knowledge sharing capability which significantly enhance the organizational performance and competitiveness.

The objectives of the study are to:

- To gain knowledge about the supply chain management system adopted in the manufacturing industry of keltron in Kerala.
- To analyse the effectiveness of procurement and supplier relationship management practices in keltron manufacturing industry.
- To discuss the importance of Inventory Control, Warehousing and Production and Distribution.
- To find out about the production planning, scheduling and distribution strategies used by keltron manufacturing industry in Kerala.

Research Methodology

The study is a descriptive and analytical research, to analyze the Supply Chain Management system practiced in KELTRON. The analysis was predominantly of secondary data gathered from company records, reports, journals, magazines and other relevant sources within the study period. The efficiency of procurement, inventory management, production planning, warehousing, logistics and distribution are analyzed with various analytical and statistical tools including Value Stream Mapping (VSM), Pareto Analysis, Supplier Performance Scorecard, Lead Time Analysis, ABC Inventory Analysis, Economic Order Quantity (EOQ), Gantt Chart, Cycle Time Analysis, Bottleneck Analysis etc. The study has a systematic approach to identify operational inefficiencies, analyse the performance of the supply chain and recommend appropriate actions to improve the overall operational efficiency and effectiveness of the organisation.

Table 1 Value Stream Mapping

Process Stage	Processing Time	Waiting Time	Total Time
Raw Material Inspection	300 sec	6 days	6 days + 300 sec
Production / Manufacturing	70 sec	4 days	4 days + 70 sec
Quality Testing	260 sec	3 days	3 days + 260 sec
Packaging & Dispatch	140 sec	5 days	5 days + 140 sec

Total Processing Time: 770 sec
Total Waiting Time: 18 days
Total Lead Time: 18 days + 770 sec
Source is secondary data

Table 1 shows that the total lead time is 18 days, while the actual processing time is only 770 seconds. Most of the time is spent on waiting activities rather than production. Raw material inspection and packaging stages contribute more to delays, whereas production activities are comparatively efficient.Pareto Analysis

Pareto Analysis helps identify the major factors causing supply chain problems based on the 80/20 principle.

Table 2 Factors Affecting Supply Chain

Factors Affecting Supply Chain	Year 1	Year 2	Year 3	Year 4	Year 5	Total Frequency	Cumulative %
Delay in raw material procurement	40	42	45	48	50	225	29.2
Supplier reliability issues	32	34	36	38	40	180	52.6
Inventory management inefficiency	25	27	29	30	32	143	71.2
Production downtime	18	20	22	23	25	108	85.2
Logistics and transportation delay	12	14	15	17	18	76	95.1
Demand forecasting issues	8	9	10	11	12	50	101

Source: Secondary Data

Table 2 indicates that delays in raw material procurement, supplier reliability issues, and inventory inefficiency are the major causes of supply chain problems. These factors together contribute nearly 70–80% of the total issues. Other factors such as logistics delay and forecasting issues have a comparatively lower impact.

Supplier Performance Scorecard

Table 3.1 Performance Criteria and Weightage

Criteria	Weight (%)
Quality	30
Delivery Reliability	20
Cost Efficiency	20
Lead Time Consistency	15
Responsiveness	15
Total	100

Source: Secondary Data

Table 3.2 Supplier Scorecard

Criteria	Weight	Supplier A	Supplier B	Supplier C	A×W	B×W	C×W
Quality	30	8	7	9	240	210	270
Delivery Reliability	20	7	8	6	140	160	120
Cost Efficiency	20	6	9	8	120	180	160
Lead Time Consistency	15	8	7	6	120	105	90
Responsiveness	15	7	6	8	105	90	120

Source: Secondary Data

Table 3.3 Final Supplier Scores

Supplier	Total Score	Percentage (%)	Rank
Supplier A	725	72.50%	3
Supplier B	745	74.50%	2
Supplier C	760	76.00%	1

Source: Secondary Data

Table 3.3 shows that Supplier C achieved the highest overall score due to better quality and responsiveness. Supplier B performed well in cost efficiency and delivery reliability, while Supplier A showed moderate performance across most criteria. The analysis helps identify the most efficient supplier for better supply chain performance.

Table 4 Lead Time Analysis

Sl. No	Process Stage	Processing Time	Waiting Time	Total Time
1	Component Procurement	4 hrs (0.17 days)	5 days	5.17 days
2	Incoming Material Checking	1.5 hrs (0.06 days)	1 day	1.06 days
3	PCB Fabrication & Assembly	5 hrs (0.21 days)	2.5 days	2.71 days
4	System Integration	3 hrs (0.125 days)	1.5 days	1.625 days
5	Testing & Quality Assurance	4 hrs (0.17 days)	2 days	2.17 days
6	Packing & Storage	2 hrs (0.08 days)	1 day	1.08 days

7	Distribution to Clients	3 hrs (0.125 days)	1 day	1.125 days
Total	—	~1 day	14 days	≈15 days

Source: Secondary Data

Table 4 shows that most of the total lead time is consumed by waiting activities rather than actual processing. Component procurement contributes the highest waiting time, followed by PCB fabrication and testing stages. This indicates the need for better coordination and procurement management.

ABC Analysis

Table 5.1 Inventory Consumption Data

Item Name	Year 1 (₹)	Year 2 (₹)	Year 3 (₹)	Year 4 (₹)	Year 5 (₹)
Semiconductor Components	1,20,000	1,28,000	1,35,000	1,42,000	1,50,500
Integrated Circuits (ICs)	95,000	1,00,000	1,05,000	1,10,000	1,15,200
Printed Circuit Boards (PCB)	45,000	48,000	52,000	55,000	58,400
Connectors & Cables	28,000	30,000	32,500	34,000	36,200
Packaging Materials	18,000	19,500	21,000	22,500	24,000
Maintenance Materials	10,000	11,000	12,500	13,500	14,800

Source: Secondary Data

Table 5.2 ABC Calculation Table

Item Name	Annual Value (₹)	% of Total	Cumulative %	Category
Semiconductor Components	1,50,500	38%	38%	A
Integrated Circuits (ICs)	1,15,200	29%	67%	A
Printed Circuit Boards (PCB)	58,400	15%	82%	B
Connectors & Cables	36,200	9%	91%	B
Packaging Materials	24,000	6%	97%	C
Maintenance Materials	14,800	3%	100%	C

Source: Secondary data

Table 5.2 shows that Semiconductor Components and ICs belong to Category A and contribute the highest inventory value. PCBs and Connectors fall under Category B with moderate importance. Packaging and Maintenance Materials belong to Category C and require minimum control.

Economic Order Quantity (EOQ)

Table 6.1 EOQ Calculation Data

Item Name	Annual Demand	Ordering Cost (₹)	Carrying Cost per Unit (₹)
Semiconductor Components	820	500	25
Integrated Circuits (ICs)	500	450	20
Printed Circuit Boards	320	400	18
Connectors & Cables	420	350	15

Source: Secondary Data

Table 6.2 EOQ Calculation

Item Name	EOQ (Units)
Semiconductor Components	181 Units
Integrated Circuits (ICs)	150 Units
Printed Circuit Boards	119 Units
Connectors & Cables	140 Units

Source: Secondary Data

Table 6.2 indicates that Semiconductor Components have the highest EOQ due to greater demand. ICs and Connectors show moderate EOQ values, while PCBs have the lowest EOQ. The analysis helps maintain optimum inventory levels and reduce inventory-related costs.

Cycle Time Analysis

Table 7.1 Cycle Time Table

Sl. No	Process Stage	Setup Time	Processing Time	Inspection Time	Total Cycle Time
1	Component Preparation	3 min	6 min	—	9 min
2	PCB Assembly & Soldering	4 min	15 min	3 min	22 min
3	In-process Testing	—	6 min	3 min	9 min
4	Final Product Assembly	3 min	8 min	2 min	13 min
5	Final Quality Inspection	—	4 min	3 min	7 min
6	Packaging & Dispatch Prep	2 min	4 min	—	6 min
Total	—	12 min	43 min	11 min	66 min

Table 7.2 Productivity Calculation

Particulars	Value
Working Hours per Day	8 hours (480 min)
Cycle Time per Unit	66 min
Units Produced per Day	≈7 units

Source: Secondary Data

Table 7.1 shows that the total cycle time per unit is 66 minutes. PCB Assembly & Soldering consumes the highest time and acts as the most critical production stage. Processing time contributes the major share of total cycle time, while setup and inspection times are comparatively lower.

Bottleneck Analysis

Bottleneck Analysis identifies the stage that restricts the overall production flow.

Table 8 Bottleneck Analysis

Sl. No	Process Stage	Cycle Time (Minutes)	Production Capacity (Units/Hour)
1	Component Preparation	8	7.5
2	PCB Assembly Process	22	2.7
3	Module Integration	10	6
4	Functional Testing	14	4.3
5	Final Quality Verification	6	10
6	Packing & Dispatch Setup	5	12

Source: Secondary Data

Table 8 shows that the PCB Assembly Process has the highest cycle time and the lowest production capacity of 2.7 units per hour. This stage slows down the entire production flow and acts as the main bottleneck in the system. Improving this process can significantly increase production efficiency.

Findings

- Using VSM, it is found that the entire lead time is 18 days, with only 770 seconds (about 13 minutes) representing the actual processing time. More than 99% of the time is unproductive waiting time, which shows the presence of serious inefficiencies in the flow of the system.
- The frequency analysis result showed that delay in raw material procurement (28.8 %), supplier reliability (cumulative 51.9 %) and inventory management inefficiency (cumulative 70.2 %) accounted for about 70% of the supply chain problems, which is known as Pareto Analysis, thus supporting the 80/20 rule.
- Supplier C is the best performer with Supplier Performance Scorecard (76.00%) due to their quality and responsiveness; following them is Supplier B (74.50%) and Supplier A (72.50%). There are no perfect suppliers in every aspect.
- The Lead Time Analysis indicates that there is around 15 days of total lead time (TLT) including 14 days of waiting time (WL) and 93% of the time is wasted. The highest waiting time (5 days) is from Component Procurement.
- The Semiconductor Components and Integrated Circuits, comprising of 67% of the inventory (₹2,65,700 out of ₹3,97,100) are classified as Category A items and the inventory control is the most stringent.
- EOQ Analysis provides the optimal quantities to be ordered for each item – which in this case are 181 for Semiconductor Components, 150 for ICs, 140 for Connectors & Cables, and 119 for PCBs, which then allows them to make optimal procurement decisions to minimize costs.
- Cycle Time Analysis shows the total production cycle time of 66 minutes/unit with PCB Assembly & Soldering being the longest cycle time (22 minutes, 33% of the total cycle time). The current production capacity is around 7 units per day.
- According to the Bottleneck Analysis, the biggest bottleneck is PCB Assembly Process, having only a capacity of 2.7 units per hour, this restricts the entire production line, even though the other stages have higher production capacity.

Suggestions

- Lean Supply Chain practice needs to be implemented at the Company to decrease the waste of time not adding value (NVA) which was identified during Value Stream Mapping (VSM). Any unnecessary approval process, holding of inventory and unnecessary delays between stages should be avoided to move the process more efficiently.

- As sourcing of raw material and reliability of suppliers become a key source of supply chain problems, the organization should improve supplier relationship management through longer term contracts, holding alternative suppliers and reviewing the performance of suppliers regularly.
- To track inventory, minimize stock-outs and prevent overstocking, the company needs to implement a digital inventory management system. Using the right inventory planning process can greatly minimize the time it takes to make purchases.
- Supplier C should be targeted for critical materials given his Supplier Performance Scorecard and Supplier A and Supplier B should be continuously monitored and guided for improvement in quality, delivery consistency and responsiveness.
- The organization should work on reducing the lead time by minimizing the waiting time between procurement, inspection and production activities. Delays can be minimised through better cross-departmental co-ordination and through better scheduling practices.
- The most valuable items (category A) identified by the ABC Analysis should be strictly monitored, stock frequently checked and priority procurement plans should be developed for these items.
- The results of the EOQ should be used in procurement planning to maintain optimal inventory levels to minimise the total inventory cost associated with ordering and storing the inventory.
- The PCB Assembly & Soldering process takes the longest time to produce, so the company should consider introducing semi-automation, skill training and enhance the layout planning of work stations to minimize cycle times for this process.
- The PCB Assembly Process was found to be the primary constraint in the Bottleneck Analysis, so more workers, more equipment, or more workstations can be added to meet production requirements and increase overall throughput.
- To improve the operational performance of the company in long term and to make the supply chains more efficient, the company must regularly monitor the company's operations and analyze the performance periodically with the help of various tools such as VSM, Pareto Analysis, ABC Analysis, and Bottleneck Analysis.

Conclusion

The study was conducted by analysing the practices in Supply chain Management at KELTRON Equipment Complex by applying different analytical tools. The results show that the problems in procurement, waiting time and the problems in PCB assembly are the leading causes of major delays. ABC Analysis and EOQ are useful tools for inventory control and cost reduction. In general, the overall performance of the supply chain system can be improved through the improvement of procurement, supplier coordination and production efficiency.

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