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A Study on Supply Chain Operations at FTC Solar Pvt. Ltd, Chennai

Ms. Ummul Shifana Nasreen H

II MBA, Department of Management Studies, Mohamed Sathak Engineering College, Kilakarai, Tamil Nadu, India

Dr. B. Meenakshi Sundaram

Associate Professor, Department of Management Studies, Mohamed Sathak Engineering College, Kilakarai, Tamil Nadu, India

ABSTRACT: Supply chain operations are vital to manufacturing efficiency, cost control, and customer satisfaction. This study evaluates procurement, logistics, inventory, and distribution at FTC Solar Private Limited using primary data from employees across key departments. Percentage analysis, Chi-square, and correlation were applied. Findings show effective vendor coordination and timely procurement, while inventory efficiency strongly contributes to on-time delivery. The study recommends digital tools, stronger vendor evaluation, real-time inventory tracking, and regular performance reviews for supply chain optimization.

KEYWORDS: Supply Chain Operations, Inventory Management, Vendor Coordination, Logistics Efficiency, Renewable Energy Manufacturing.

I. INTRODUCTION

Supply chain operations manage the flow of materials, information, and products from suppliers to customers. At FTC Solar, key activities include procurement, inventory management, warehousing, transportation, order processing, quality control, and distribution. Approved suppliers are selected based on cost, quality, and delivery performance. FIFO and regular stock verification support inventory efficiency. Organized warehousing, route planning, digital tracking, and quality inspections improve operations. Performance is monitored through delivery time, costs, and inventory turnover, while risk management ensures continuity and minimizes disruptions.

Statement of the Problem

FTC Solar India Pvt. Ltd., Chennai faces supply chain challenges involving inventory control, warehouse inefficiencies, transportation delays, distribution issues, and rising operational costs. This study evaluates these interconnected functions, identifies operational gaps, and recommends effective inventory, logistics, warehouse, and cost-reduction strategies to improve overall supply chain efficiency.

Objectives of the Study

The objectives of this study are

1. To study the supply chain operations at FTC Solar India Pvt. Ltd., Chennai.
2. To evaluate inventory management practices and control systems in supply chain operations.
3. To analyze the efficiency of warehouse operations and control systems in supply chain management.
4. To assess transportation and distribution processes for ensuring timely delivery.
5. To suggest effective cost-reduction strategies for improving supply chain operations.

Scope of the Study

1. Analyze FTC Solar's supply chain operations, including procurement, inventory, warehousing, and distribution activities.
2. Evaluate inventory, warehouse, transportation, and distribution efficiency for optimal operations and delivery.
3. Study interdepartmental coordination and its impact on overall supply chain performance.

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Limitations of Study

1. Study coverage is limited to selected supply chain departments within the organization.
2. Limited respondents, time constraints, subjective responses may affect reliability of findings.
3. Confidential data and specific operational aspects limited comprehensive supply chain analysis.

II. REVIEW OF LITERATURE

Biyouki, Rezania et al. (2024), in their study titled "Solar Photovoltaics Value Chain and End-of-Life Management Practices: A Systematic Review," published in Sustainability (Vol. 16, Issue 16), concluded that value-chain integration improves cost efficiency and sustainability in solar supply chain operations.

Hmouda et al. (2024), in their study titled "Sustainable Supply Chain Management in Energy Production," published in Renewable and Sustainable Energy Reviews (Vol. 191), concluded that coordination gaps between suppliers and logistics providers negatively affect operational performance in energy companies.

Raygoza-Limón et al. (2025), in their study titled "Supply Chain Management in Renewable Energy Projects from a Life Cycle Perspective," published in Applied Sciences (Vol. 15, Issue 9), concluded that life-cycle-based supply chain analysis helps reduce environmental impacts and improve resource utilization.

Younes et al. (2025), in their study titled "Impact of Supply Chain Management on Energy Transition and Environmental Sustainability," published in Sustainability (Vol. 17, Issue 20), concluded that effective supply chain integration supports energy transition and sustainable operational growth..

Industry Profile

The growing solar energy industry relies on efficiency and technology like solar tracking systems to meet clean power demand. In this competitive market, key players like FTC Solar specialize in advanced tracking solutions. Success depends heavily on optimized supply chains—including raw material procurement, inventory management, and transportation—to ensure timely delivery and operational excellence.

Industry Scenario

The solar energy industry is expanding rapidly due to rising demand for clean energy and technological advancements. Efficient procurement, inventory, warehousing, transportation, and distribution are essential for operational success.

Global Scenario

FTC Solar is a leading global solar tracker company, competing with major players such as Nextracker and Array Technologies. Its global operations emphasize high-wind trackers, AI-enabled software, supply-chain localization, and international contracts.

National Scenario

India is emerging as a major solar market, supported by government initiatives and increasing investments. FTC Solar India benefits from growing utility-scale projects while addressing regulatory and supply-chain challenges.

State Scenario

Tamil Nadu provides strong infrastructure and logistics connectivity, while Rajasthan and Gujarat offer significant opportunities for solar projects and manufacturing.

Future Outlook

FTC Solar's future depends on innovation, digital technologies, localized manufacturing, automation, and efficient supply-chain management, supporting sustainable growth through 2030.

FTC Solar Pvt. Ltd, Chennai, - **Brief Profile**

FTC Solar founded in 2017, is a global provider of advanced solar tracking systems, software, and engineering services. FTC Solar India Pvt. Ltd., headquartered in Chennai, supports utility-scale projects through engineering, administration, logistics, and project execution. Its products include Pioneer 1P, Voyager 2P, tracker assemblies, and SunTracking software. The company emphasizes innovation, supply-chain efficiency, sustainability, and international growth.

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Research Design
The study adopts a descriptive research design to collect, analyze, interpret, and report data systematically.

Source of Data
Both primary and secondary data were used. Primary data were collected through a structured questionnaire. Secondary data were obtained from the company website, internet sources, and journals.

Research Approach
A survey method was adopted to collect information from selected respondents through their responses to structured questions.

Research Instrument
A questionnaire was used as the main instrument for collecting primary data.

Sample Plan
The sample unit consists of employees of FTC Solar Pvt. Ltd., Chennai. The sample size was 115 respondents selected from a population of 223 employees.

Sampling Procedure
Simple Random Sampling was used, providing every employee with an equal opportunity for selection in the study.

Tools Used for Data Analysis
Percentage Analysis: Percentage analysis was used to analyze demographic characteristics and respondents options regarding supply chain operations.

$$\text{Percentage} = \frac{\text{No.of Respondents in a Category}}{\text{Total No.of Respondents}} \text{ x } 100$$

Chi-Square Test: Chi-square determines whether variables are associated, including analytics usage, performance, awareness, decision-making, and departmental usage.

$$\chi^2 = \frac{\sum (0i - Ei)^2}{Ei}$$

Correlation Analysis
Correlation analysis is a statistical tool used to measure the relationship between two variables. It is denoted by "r" and shows the strength and direction of the relationship. It helps to identify whether variables such as business analytics usage and organizational performance are related

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2}}$$

Data Analysis and Interpretation
Data analysis involves systematically organizing and examining data to answer research questions, often using visual tools like tables and charts. Data, collected through various methods, is meaningless until analyzed. Analysis identifies patterns and insights through techniques like classification and comparison. Interpretation gives meaning to findings, aligns them with research goals, and generates insights for informed decision-making and future studies.

Table: 1 Designation

Designation	No. of Respondents	%
Executive	15	13
Supervisor	20	17
Operators	20	17
Analyst	25	23
Labour	35	30
Total	**115**	**100**

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The table shows labour respondents highest at 30%, followed by analysts 23%, supervisors 17%, operators 17%, and executives 13%.

Table: 2 Department wise Classification

Department wise clients	No. of Respondents	%
Procurement	22	19
Warehouse	30	26
Logistics	15	13
Transportation	28	25
Order Picking	20	17
Total	**115**	**100**

It is observed that 19% of the clients are involved in procurement, 26% in warehouse, 13 % in Logistics, 25 % in Transportation and 17 % in Order Picking

Table: 3 Years of Experience

Years of Experience	No. of Respondents	%
Below 1 year	35	31
1–3 years	27	24
3–5 years	20	17
5–10 years	25	21
Above 10 years	8	7
Total	**115**	**100**

Most respondents have below one-year experience (31%), while 7% possess above ten years, indicating relatively less experienced workforce.

Table: 4 Respondents Opinion about Supply Chain Operational Factors

Supply Chain Operational Factors	Very High		High		Moderate		Low		Very Low	
	Res *	%	Res *	%	Res *	%	Res *	%	Res *	%
Supplier Reliability	28	24	40	36	32	28	10	8	5	4
Cost Efficiency in Procurement	40	36	28	24	32	28	10	8	5	4
Efficiency in Transportation	30	26	38	33	27	24	15	13	5	4

The table shows that supplier reliability has the highest High rating with 40 respondents (36%), while transportation efficiency has 38 respondents (33%). Cost efficiency in procurement records the highest Very High rating with 40 respondents (36%), indicating strong perceived procurement performance.

Table: 5 Delivery of Raw Material

Delivery of Raw Material	No. of Respondents	%
Always on time	60	55
Mostly on time	42	36
Sometimes delayed	8	6
Often delayed	5	3
Total	**115**	**100**

The table indicates that 60 respondents (55%) receive raw materials always on time, while 42 (36%) report mostly on-time delivery. Only 8 respondents (6%) experience occasional delays, and 5 (3%) face frequent delays, showing that raw material delivery is generally efficient.

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Table: 6 Respondents Opinion on effectiveness on supply chain factors

Effectiveness Supply Chain Factors	Excellent		Good		Average		Poor		Very Poor	
	Res *	%	Res *	%	Res *	%	Res *	%	Res *	%
Supplier Communication	55	48	45	39	12	10	3	3	0	0
Warehouse Layout	32	28	38	33	25	22	12	10	8	7
Safety @ Warehouse	34	29	42	37	30	26	9	8	0	0
Department Coordination	32	28	38	33	27	23	18	16	0	0
Overall Operation Efficiency	34	30	38	33	26	23	17	15	0	0
Training to employees	50	44	43	37	20	17	2	2	0	0

Supplier communication records the highest excellent rating at 55 respondents (48%), followed by training at 50 (43%). Good ratings remain strong, indicating effective supply chain performance overall.

Table: 7 Inventory Track System

Inventory Track System	No. of Respondents	%
Fully automated	40	35
Partially automated	50	43
Manual	25	22
Total	**115**	**100**

It is interpreted that 35 % of inventory track system is fully automated, 43 % is partially automated and 22 % is managed manually.

Table: 8 Frequency of Stock Verification

Frequency of Stock Verification	No. of Respondents	%
Daily	28	24
Weekly	34	30
Monthly	30	26
Quarterly	15	13
Rarely	8	7
Total	**115**	**100**

The table shows that 34 respondents (29%) conduct stock verification weekly, followed by 30 respondents (26%) monthly and 28 (24%) daily. 15 respondents (13%) verify quarterly, while 8 (7%) do so rarely, indicating regular stock monitoring.

Table: 9 Occurrence of Shortage of Stock

Occurrence of Shortage of Stock	No. of Respondents	%
Never	42	37
Rarely	51	44
Often	22	19
Total	**115**	**100**

The table shows that 51 respondents (44%) rarely experience stock shortages, while 42 (36%) never face shortages. Only 22 respondents (19%) experience shortages often, indicating effective stock management overall.

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Table: 10 Efficiency on Material Handling

Efficiency on Material Handling	No. of Respondents	%
Efficient	48	42
Moderately efficient	42	36
Inefficient	25	22
Total	**115**	**100**

The table indicates that 48 respondents (42%) consider material handling efficient, while 42 respondents (36%) rate it moderately efficient. 25 respondents (22%) find it inefficient, showing generally satisfactory material-handling performance.

Table: 11 Delivery Performance

Delivery Performance	No. of Respondents	%
Always on time	72	63
Sometimes delayed	43	37
Always delayed	0	0
Total	**115**	**100**

The table shows that 72 respondents (63%) report deliveries are always on time, while 43 respondents (37%) experience occasional delays. No respondents reported always-delayed deliveries, indicating strong overall delivery performance.

Table: 12 Level of Technology used in SCM

Level of Technology used in SCM	No. of Respondents	%
Advanced	70	60
Basic	45	40
Total	**115**	**100**

The table indicates that 70 respondents (60%) report using advanced technology in supply chain management, while 45 respondents (40%) use basic technology. No respondents reported technology being unused, indicating complete technology adoption in SCM.

Table: 13 Availability of Real Time Tracking

Availability of Real Time Tracking	No. of Respondents	%
Fully available	42	37
Mostly available	38	33
Sometimes available	25	22
Rarely available	10	8
Total	**115**	**100**

The table shows that 42 respondents (36%) report real-time tracking is fully available, while 38 (33%) say mostly available. 25 (22%) report occasional availability, and 10 (8%) indicate rare availability, showing generally good tracking accessibility.

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Table: 14 Overall satisfaction of Supply Chain Operations

Overall satisfaction of Supply Chain Operations	No. of Respondents	%
Highly satisfied	50	43
Satisfied	40	36
Neutral	20	17
Dissatisfied	5	4
Highly dissatisfied	0	0
Total	**115**	**100**

The table shows that 50 respondents (43%) are highly satisfied and 40 (36%) are satisfied with supply chain operations. 20 (17%) are neutral, while only 5 (4%) are dissatisfied, indicating high overall satisfaction.

III. CHI SQUARE TEST–I

Relationship between Department and Overall Satisfaction with Supply Chain Operations

Null hypothesis: H0:

There is no significant relationship between Department and Overall satisfaction with supply chain operations

Alternative hypothesis: H1:

There is significant relationship between Department and Overall satisfaction with supply chain operations

Observed frequency

The observed frequency for Chi Square Test is given in the table below:

Table 15: Observed Frequency

Department	Overall Satisfaction of Supply Chain Operations					Total
	Highly Satisfied	Satisfied	Neutral	Dissatisfied	Highly Dissatisfied	
Procurement	9	8	4	1	0	**22**
Warehouse	14	10	5	1	0	**30**
Logistics	6	5	3	1	0	**15**
Transportation	13	10	4	1	0	**28**
Order Picking	9	7	4	1	0	**20**
Total	**50**	**40**	**20**	**5**	**0**	**115**

Source: Primary Data

$$\textbf{Expected Frequency} = \frac{\textbf{Row Total x Coloum Total}}{\textbf{Grand Total}}$$

Applying the row value and column value for each row and column using the above formula, the following expected frequency is arrived.

Table 16: Expected Frequency

Department	Overall Satisfaction of Supply Chain Operations					Total
	Highly Satisfied	Satisfied	Neutral	Dissatisfied	Highly Dissatisfied	
Procurement	09.57	07.65	03.83	0.96	0	**22**
Warehouse	13.04	10.43	05.22	1.30	0	**30**
Logistics	06.52	05.22	02.61	0.65	0	**15**
Transportation	12.17	09.74	04.87	1.22	0	**28**

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Order Picking	08.70	06.96	03.47	0.87	0	**20**
Total	**50**	**40**	**20**	**5**	**0**	**115**

$$\chi^2 = \frac{\sum (0i - Ei)^2}{Ei}$$

Table 17: Calculation of Chi Square

Observed frequency	Expected frequency	Oi–Ei	$(Oi–Ei)^2$	$(Oi–Ei)^2/Ei$
9	09.57	-0.57	0.3249	0.0339
8	07.65	0.35	0.1225	0.0160
4	03.83	0.17	0.0289	0.0075
1	0.96	0.04	0.0016	0.0017
14	13.04	0.96	0.9216	0.0707
10	10.43	-0.43	0.1849	0.0177
5	05.22	-0.22	0.0484	0.0093
1	01.30	-0.3	0.09	0.0692
6	06.52	-0.52	0.2704	0.0415
5	05.22	-0.22	0.0484	0.0093
3	02.61	0.39	0.1521	0.0583
1	00.65	0.35	0.1225	0.1885
13	12.17	0.83	0.6889	0.0566
10	09.74	0.26	0.0676	0.0069
4	04.87	-0.87	0.7569	0.1554
1	01.22	-0.22	0.0484	0.0397
9	08.70	0.3	0.09	0.0103
7	06.96	0.04	0.0016	0.0002
4	03.47	0.52	0.2704	0.0777
1	00.87	0.13	0.0169	0.0194
115			**Total**	**0.8899**

$\sum[(Oi–Ei)^2/Ei] = 0.8899$
Degrees of freedom = (No. of Rows – 1) (No. of Columns – 1) = (5-1) x (5-1) = 16
At 5% level of significance the value is 23.685 Calculated value = 0.8899
Table value > Calculate value, H0 is accepted

Inference
Hence, there is no significant relationship between Department and Overall satisfaction with supply chain operations.

Coefficient of Correlation
Correlation coefficient is the statistical tools used to measures the degree to which two variables are linearly related to each other. Correlation measures the degree of association between two variables.

Table 17 Relationship between Years of Experience and Training provided to Employees

Years of Experience (X)	Training provided (Y)	X^2	Y^2	XY
35	50	1225	2500	1750
27	43	729	1849	1161
20	20	400	400	400
25	2	625	4	50
8	0	64	0	0
$\sum X = 115$	**$\sum Y = 115$**	**$\sum X^2 = 3043$**	**$\sum Y^2 = 4753$**	**$\sum XY = 3361$**

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Source: Primary Data
Formula:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2}}$$

Calculated value = **0.7816**

Interpretation
The correlation coefficient (r = 0.7816) indicates a strong positive relationship between Years of Experience and Training provided to Employees.

Suggestions for Better Prospects
FTC Solar should automate inventory management and real-time tracking to improve accuracy and visibility. Supplier evaluation and performance monitoring should be strengthened for reliable procurement. Advanced route planning can reduce transportation delays and costs. Cross-functional collaboration should be enhanced through shared dashboards and regular meetings. Equal employee training, lean practices, cost controls, safety audits, and warehouse layout reviews should be implemented.

IV. CONCLUSION

The study concludes that FTC Solar India Pvt. Ltd., Chennai demonstrates effective supply chain operations, supporting timely delivery, inventory control, technology adoption, and employee satisfaction. However, improvements are needed in inventory automation, transportation delays, interdepartmental coordination, and cost management. Addressing these areas can enhance supply chain efficiency, productivity, employee confidence, competitiveness, and long-term organizational growth.

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