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Optimization of Transportation and Warehousing Operations at V.V. Titanium Pigments Private Limited, Thoothukudi

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ABSTRACT

Efficient logistics management is a critical determinant of organizational success in today's competitive business environment. This study investigates the optimization of transportation and warehousing operations at V.V. Titanium Pigments Pvt. Ltd. (VVTi), a leading Indian manufacturer of Titanium Dioxide located at Thoothukudi, Tamil Nadu. Primary data were collected from 150 respondents using a structured questionnaire, with disproportionate stratified random sampling. Statistical tools including Simple Percentage Analysis, Chi-Square Test, Correlation, and ANOVA were employed. Findings reveal that 44% of respondents rated warehouse goods and services as 'Good', 55.3% rated real-time shipment visibility as 'Very Important', and 64% agreed that warehouse systems generate high return on investment. Loading/unloading cost (30%) emerged as the highest contributor to total physical distribution cost, and improvement of traffic infrastructure (22%) was identified as the most critical issue to be addressed. The study concludes with actionable recommendations for adopting Warehouse Management Systems (WMS), Just-in-Time supplier strategies, and multimodal transportation frameworks to enhance supply chain efficiency.

Keywords: *Transportation Optimization, Warehousing Operations, Logistics Management, Supply Chain, Warehouse Management System (WMS), V.V. Titanium Pigments.*

I. INTRODUCTION

In today's highly competitive business environment, efficient logistics management has become a critical factor for organizational success. Transportation and warehousing are two core components of the supply chain that directly influence operational efficiency, customer satisfaction, and overall profitability. With the rapid growth of global trade, e-commerce, and industrial expansion, organizations are increasingly focusing on optimizing these functions to reduce costs and improve service quality.

Transportation involves the movement of goods from one location to another, while warehousing refers to the storage and handling of goods until they are needed. Together, they form the backbone of logistics operations. Inefficiencies in either area can lead to delays, increased costs, inventory mismanagement, and customer dissatisfaction. Technological advancements such as automation, data analytics, GPS tracking, and Warehouse Management Systems (WMS) have significantly transformed logistics, enabling organizations to streamline processes and make data-driven decisions.

Transportation optimization focuses on route planning, load optimization, modal selection (road, rail, air, or sea), and real-time tracking. Warehousing optimization addresses space utilization, handling time, inventory accuracy, and the adoption of tools like barcode systems, RFID, and WMS. Together, these improvements help reduce carbon emissions, enhance resilience against supply chain disruptions, and meet evolving customer expectations.

II. OBJECTIVES OF THE STUDY

Primary Objective: To analyze and improve the efficiency of transportation and warehousing operations at V.V. Titanium Pigments Pvt. Ltd., Thoothukudi.

Secondary Objectives:

(1) To study the objectives of efficient warehousing operations with respect to the company.

(2) To study the warehousing network strategies followed in the organization.

(3) To analyze the loading and unloading methods adopted for material handling in the warehouse.

(4) To evaluate the effect of transport management on supply chain performance.

III. REVIEW OF LITERATURE

Azadeh et al. (2018) reviewed robotized and automated warehouse systems in the context of e-commerce, categorizing research into system analysis, design optimization, and operational planning. They identified integrated systems as the future direction for warehouse automation to meet demands for small orders and tight delivery schedules.

Randolph (2018) defined multimodal transport as the carriage of goods by at least two different transport modes under a single contract, emphasizing its role in facilitating international trade and reducing transit complexity, particularly for developing nations.

Frazell (2019) defined the warehouse mission as a combination of storage and throughput at minimum resource cost, introducing the Inventory Flow Impact Test (IFIT) to identify key warehouse resources that have a critical bottleneck potential affecting goods flow, quality, and cost.

Gu et al. (2020) introduced the concept of 'finite capacity' in warehouse resources, arguing that when resource demand exceeds capacity without proactive management intervention, it becomes a permanent operational constraint, necessitating redesign of warehouse processes.

Tsui and Chang (2020) classified truck-to-dock assignment and scheduling of loading/unloading trucks as part of receiving and shipping operations, noting the scarcity of research in this area and the growing role of cross-docking in reducing inventory and automating sorting.

MarkKoryagin (2021) argued that transportation, warehousing, and inventory are interdependent system elements—reducing inventory levels by decreasing warehouse count increases transportation costs, highlighting the need for a holistic systems approach to logistics management.

Rouwenhorst et al. (2023) revisited warehouse resource classification, noting the absence of a conceptual definition based on resource attributes, which limits the development of a useful typology for warehouse management decisions.

Webster (2025) highlighted that landlocked countries and developing nations face persistent challenges in accessing multimodal transport services despite reductions in maritime transport costs, emphasizing the growing importance of logistics infrastructure for international competitiveness.

IV. RESEARCH METHODOLOGY

This study adopts a descriptive research design to examine the transportation and warehousing operations at VVTi. Primary data were collected through face-to-face interviews using a structured questionnaire administered to 150 respondents using disproportionate stratified random sampling. Secondary data were gathered from published literature, company records, magazines, and online sources.

The following statistical tools were used for data analysis:

(1) Simple Percentage Analysis — to describe the frequency distribution of responses.

(2) Chi-Square Test — to test the significance of associations between categorical variables.

(3) Correlation — to measure the strength and direction of relationships between variables.

(4) ANOVA — to compare means across multiple groups and test for significant differences.

V. DATA ANALYSIS AND INTERPRETATION

5.1 Demographic Profile

Table 1: Gender of the Respondents

Gender	No. of Respondents	Percentage (%)
Male	97	64.7%
Female	53	35.3%
Total	150	100.0%

Majority 64.7% of the respondents are male, reflecting the male-dominant nature of chemical manufacturing and logistics operations.

Table 2: Age of the Respondents

Age Group	No. of Respondents	Percentage (%)
Below 25 years	15	10.0%
25 to 35 years	64	42.7%
35 to 45 years	48	32.0%
Above 40 years	23	15.3%
Total	150	100.0%

The majority 42.7% of respondents fall in the 25–35 years age group, indicating a workforce in its most productive phase with substantial field experience.

Table 3: Educational Qualification

Qualification	No. of Respondents	Percentage (%)
Graduate	53	35.3%
Post Graduate	37	24.7%
Diploma	31	20.7%
Others	29	19.3%
Total	150	100.0%

Graduate respondents form the largest group (35.3%), suggesting a relatively educated workforce capable of adapting to modern logistics technologies and systems.

5.2 Warehousing Operations Analysis

Table 4: Warehouse Goods and Service

Rating	No. of Respondents	Percentage (%)
Excellent	57	38.0%
Good	66	44.0%
Moderate	20	13.3%
Poor	7	4.7%
Total	150	100.0%

A combined 82% of respondents rated warehouse goods and services as 'Good' or 'Excellent', indicating a generally satisfactory level of warehousing performance at VVTi.

Table 5: Storage Capacity Utilization

Level	No. of Respondents	Percentage (%)
Very High	53	35.3%
High	51	34.0%
Moderate	27	18.0%
Low	19	12.7%
Total	150	100.0%

69.3% of respondents feel the storage systems enable 'Very High' or 'High' utilization of warehouse cubic capacity, demonstrating effective space management practices.

VI. STATISTICAL ANALYSIS

6.1 Chi-Square Analysis

H_0: There is no significant relationship between age of respondents and warehouse goods and service. H_1: There is a significant relationship between age of respondents and warehouse goods and service.

Table 6: Chi-Square Test Results

Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	202.5	9	.000
Likelihood Ratio	204.006	9	.000
Linear-by-Linear	107.501	1	.000
N of Valid Cases	150		

The Pearson Chi-Square value is 202.5 with p = .000. However, the cross-tabulation reveals a strong age- based patterning (e.g., respondents below 25 years uniformly rated warehouse service as 'Excellent'), with Gamma = 1.000 indicating a perfect ordinal association. Since $p < 0.05$, the null hypothesis is rejected at the 5% significance level: age is significantly associated with the perceived quality of warehouse goods and service.

6.2 Correlation Analysis

The Pearson correlation between Educational Qualification and perception of Logistics Operation Efficiency was $r = 0.947$ ($p < 0.01$). Spearman's rho = 0.965 and Kendall's tau_b = 0.931, both statistically significant at the 0.01 level. This strong positive correlation indicates that higher educational qualification is associated with a more favourable perception of logistics operation efficiency at VVTi — reflecting the role of education in understanding and evaluating complex supply chain functions.

6.3 ANOVA

H_0: There is no significant relationship between experience of respondents and perception of logistics operation.

H_1: There is a significant relationship between experience of respondents and perception of logistics operation.

Table 7: ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	85.844	3	28.615	162.881	.000
Within Groups	25.649	146	0.176		
Total	111.493	149			

The F-value is 162.881 ($p < 0.05$). The null hypothesis is rejected. There is a statistically significant relationship between years of experience and perception of logistics operation efficiency. Post-hoc analysis (Student-Newman-Keuls and Tukey B) confirms that respondents in each experience group perceive logistics efficiency distinctly, suggesting that operational experience shapes employees' understanding and evaluation of logistics performance.

VII. FINDINGS

The key findings from this study are summarized as follows:

(1) 64.7% of respondents are male, with the largest age group (42.7%) being 25–35 years, and 43.3% having 2–5 years of experience.

(2) 35.3% of respondents are graduates, reflecting a reasonably educated logistics and warehousing workforce.

(3) 30% of respondents source raw materials from some locations inside the country, relying on sister concern VV Mineral for Ilmenite supply.

(4) 82% of respondents rated warehouse goods and services as 'Good' or 'Excellent'.

(5) 69.3% of respondents reported 'Very High' or 'High' storage capacity utilization.

(6) 69.3% perceived logistics operations as running 'Very Efficiently' or 'Efficiently'.

(7) 88.6% rated real-time shipment visibility as 'Very Important' or 'Extremely Important'.

(8) 46.7% agreed that WMS improves inventory accuracy; 46.0% strongly agreed that WMS enhances customer satisfaction.

(9) 64.0% agreed that warehouse systems provide a high return on investment — the strongest consensus in the study.

(10) 38.0% strongly agreed that WMS increases speed for material handling.

(11) Truckload (26%) is the dominant transportation mode used by VVTi.

(12) Loading/unloading cost is the largest contributor (30%) to total physical distribution cost.

(13) Improvement of traffic (22%) and container terminal capacity (21.3%) are the top infrastructure priorities identified.

(14) Rail network improvement received the highest strong agreement (44%) among proposed transportation improvement measures.

(15) High implementation cost (34.7%) is the leading barrier to WMS adoption.

VIII. SUGGESTIONS

(1) VVTi should consider implementing a phased Warehouse Management System (WMS) to improve inventory accuracy, reduce paperwork, and enhance customer satisfaction. A cloud-based WMS can reduce upfront capital costs while delivering measurable returns.

(2) To address the high loading/unloading cost (30% of total distribution cost), VVTi should invest in mechanized dock levelers, conveyor systems, and forklifts to reduce labor intensity and turnaround time.

(3) The company should convert key suppliers into Just-in-Time (JIT) suppliers to manage demand fluctuations efficiently, reduce excess inventory, and improve supply chain responsiveness.

(4) Given the high endorsement for rail network improvement (44%), VVTi should explore rail-road multimodal integration for bulk chemical shipments to reduce transportation costs and carbon footprint.

(5) Real-time GPS-based shipment tracking systems should be deployed across the company-owned truck fleet to provide supply chain visibility and proactively manage delivery disruptions.

IX. CONCLUSION

This study provides a comprehensive assessment of transportation and warehousing operations at V.V. Titanium Pigments Pvt. Ltd., a major chemical manufacturer operating in the competitive global TiO2 market. The findings confirm that VVTi's existing logistics infrastructure is performing at a generally satisfactory level, with strong warehouse utilization, competent logistics management, and high employee awareness of the importance of real-time visibility. However, significant opportunities for optimization exist in loading/unloading cost reduction, WMS adoption, multimodal transportation integration, and traffic infrastructure improvement.

The statistical analyses—Chi-Square, Correlation, and ANOVA—collectively demonstrate that demographic variables such as age, education, and experience significantly shape employee perceptions of logistics performance. This underscores the importance of targeted training and change management strategies when implementing new logistics technologies. By adopting the recommendations in this study, VVTi can enhance supply chain resilience, reduce operational costs, and strengthen its competitive position in both domestic and international markets.

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