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A Study on Operational Efficiency of Cold Supply Chain Service Providers with Special Reference to Selected Container Operators

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ABSTRACT

The demand for cold supply chain services has surged with the global expansion of perishable goods trade. Efficient management of temperature-sensitive products relies heavily on the operational performance of cold supply chain service providers. This study aims to evaluate the operational efficiency of selected container operators within the cold supply chain domain. Employing a mixed-methods approach, quantitative data will be collected through financial performance metrics, operational indicators, and customer satisfaction surveys. Additionally, qualitative insights will be gathered through interviews with industry experts and key stakeholders. By analysing the collected data, this research seeks to identify factors influencing operational efficiency, challenges faced by container operators, and best practices for enhancing performance. The findings of this study will contribute to the development of strategies for improving operational efficiency in the cold supply chain sector, ultimately benefiting both service providers and stakeholders.

KEYWORDS: Temperature, Container, Pharmaceuticals, Biotechnology, Storage Facilities, Coimbatore, Tirupur

1. INTRODUCTION

India faces challenges in effectively providing food to its large population, despite being the second largest producer of fruits and vegetables. Approximately twenty-five to thirty percent of food is lost due to insufficient transportation and distribution infrastructure, such as inadequate cold storage facilities and transport fleets. The integration of Internet of Things (IoT) technologies, such as Radio-frequency identification (RFID), Wireless sensor networks (WSN), and Cloud computing, presents promising solutions to tackle these issues. By utilizing sensors, actuators, and other IoT devices, Cyber-Physical Systems (CPS) enable more intelligent and efficient information exchange throughout the value chain, benefiting both companies internally and stakeholders across sectors. In critical sectors like ports, where efficiency in loading and unloading operations is essential, digitization is crucial

for infrastructure development while addressing environmental and community concerns. The digital economy is reshaping transportation by improving efficiency, transparency, and traceability, thereby reducing negative impacts like accidents, environmental harm, and congestion. However, transitioning to digitization requires careful planning and reengineering of business processes to maintain competitiveness while considering social and environmental impacts. The significance of leveraging available technologies, as seen in advancements in vaccine technology combating diseases like smallpox, underscores the importance of utilizing innovations to safeguard public health.

OBJECTIVE

- To identify the efficiency of cold supply chain operators.
- To analyse the operational efficiency in cold supply chain in the logistics industry
- Evaluating the impact of efficiency on overall performance in cold supply chain

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2. LITERATURE REVIEW

There are numerous works that have been done related to image processing machine learning algorithms.

AU Khan, Y Ali(2023) The cold supply chain (CSC) encompasses a series of temperature-sensitive processes, spanning from raw material supply to manufacturing and ultimately the delivery of finished goods to consumers through transportation services. Pandemics like COVID-19 present significant challenges to the smooth functioning of CSCs. To address this issue, this study aims to propose resilience strategies to sustainably manage CSC operations. Through an extensive literature review, disruptions caused by COVID-19 in CSCs and resilient sustainability strategies were identified and analyzed using the Fuzzy Quality Function Deployment (QFD) technique. The findings highlight "crisis simulation," "logistics identification and security," and "digitalization of the cold supply chain" as the top three strategies to enhance CSC resilience during disruptions such as those induced by COVID-19. The study offers recommendations to policymakers to implement these strategies, ensuring a resilient and efficient CSC. This study represents a pioneering effort in applying such strategies, particularly in developing contexts

Marco Remondino, Alessandro Zanin (2022), This paper explores logistics challenges in the agri-food sector and reviews literature on the role of digitization in enhancing supply chain management and sustainability. It addresses two main research questions: the contribution of digitization to logistics efficiency and sustainability, and the strategic implications for the agri-food sector in terms of cost reduction and optimization. The case study of Italy is presented, highlighting regional logistical differences and the significance of the agri-food sector, where digitization is expected to enhance value creation and sustainability.

Jia-Wei Han , Min Zuo , Wen-Ying Zhu , Jin-Hua Zuo , En-Li Lü , Xin-Ting Yang (2021) Cold chain logistics (CCL) plays a crucial role in preserving the quality and safety of fresh agricultural products, minimizing losses, and bolstering farmers' income, thereby fostering rural industry revitalization in China. Recent research has concentrated on enhancing CCL efficiency and sustainability, offering valuable insights into fostering innovation, adopting technologies, enhancing infrastructure and equipment, and refining management practices within the CCL sector.

Neeraj Kumar, Mohit Tyagi, R K Garg, Anish Sachdeva & Dilbagh Panchal (2021) Efficient vaccine supply chains are vital for successful immunization programs worldwide. This research identifies key factors contributing to underperforming vaccine cold chains and offers systematic solutions. Utilizing the Delphi method, eight critical criteria and five alternatives for improvement are identified. Analytic Hierarchy Process (AHP) is then employed to prioritize these criteria, while the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) ranks the alternatives. The study emphasizes the importance of addressing factors like vaccine instability and advocates for continuous monitoring of cold chain functionality to enhance performance.

RD Raut, BB Gardas, VS Narwane (2019) This article proposes a fuzzy Multi-Criteria Decision Making approach to reduce food losses in the fruits and vegetable supply chain by evaluating and selecting cold-third party logistics providers (CTPLs). Through literature review and expert opinion, criteria and sub-criteria were identified, with 'Refrigerator and

loading capacity' and 'Knowledge and Information technology management' emerging as significant factors. The findings aim to guide food industry managers, CTPLs, and government agencies in formulating strategies for more efficient food supply chains, with future scope for extending the study to other developing countries and enhancing model reliability

Baoyang Ding (2018) The adoption of Pharma Industry 4.0 technologies enables sustainable value creation and enhances agility, personalization, and competitiveness in the pharmaceutical industry. This study identifies barriers to sustainable pharmaceutical supply chains (PSCs) and explores how Industry 4.0 solutions can address these challenges, including improving flexibility, coordination, waste reduction, and decision-making processes. Future research should focus on cross-linking coordination, eco-friendly disposal, proactive recall management, sustainable performance metrics, regulatory design, and incentives' impact on sustainability.

JOHN LLOYD, JAMES CHEYNE, (2017), International efforts in the 1960s and 1970s to eradicate smallpox laid the groundwork for expanding immunization programs and developing vaccine supply chains. Challenges in keeping vaccines cold during transport led to innovations in temperature monitoring, refrigeration equipment, and human resource development. Lessons learned include the need for integration with other health supplies, efficiency improvements, and long-term efforts to eliminate refrigeration dependence in the supply chain.

Samuel Mercier Sebastien Villeneuve, Martin Mondor, Ismail Uysal (2017) his study reviews the efficiency of cold chains in preserving perishable foods, highlighting frequent temperature abuses that increase food waste and safety risks. Major weaknesses include precooling, ground operations, retail display, and domestic refrigeration, with proposed solutions focusing on improved temperature management and responsive inventory systems. Prospective research aims to enhance precooling uniformity, develop inventory management systems, and optimize cold chains globally.

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However there has been little to no work put into the viability of image processing to achieve electronic automated invoicing.

3. METHODOLOGY

RESEARCH METHODS

Type Of Research : Analytical Research
Sample Design : Simple Random Sampling
Area Of The Study : Coimbatore & Tirupur
Statistic Tools : Simple Frequency Analysis, Anova

Data : Primary Data And Secondary Data

Scope of the study

The study aims to analyse the operational efficiency of cold supply chain service providers, focusing on selected container operators, evaluating their processes, technology utilization, compliance, cost efficiency, and customer satisfaction to identify areas for improvement and best practices.

Limitation of the study

- Limitation for the study could be the availability of comprehensive and accurate data from selected container operators, potentially impacting the depth of analysis and the ability to draw robust conclusions about operational efficiency. Additionally, the study may face challenges in obtaining complete access to proprietary information and internal operational processes of the container operators, potentially limiting the scope of the researchAdditionally, they can also specify the image processing library, output folder and output file format via the command line itself.
- **Area of the study**

  One area of focus for the study could Be transportation & storage in the cold supply chain, particularly within the operations of selected container operators. This would involve examining specific points in the supply chain where delays, inefficiencies, or disruptions commonly occur, and assessing their impact on overall operational efficiency.

ANALYSIS & INTERPRETATION:

1. Simple percentage Frequency

1.1 Business profile of the respondents

SI NO	PARTICULAR	NO OF RESPONDENTS	PERCENTAGE
Location			
1	Tirupur	45	40.5
2	Coimbatore	66	59.5
Years of operation			
3	1-5 years	20	18
4	6-10 years	45	40.5
5	11-15 years	22	19.8
6	Above 15 years	24	21.6
No of containers			
7	1-5 containers	25	22.5
8	6-10 containers	59	53.2
9	More than 10 containers	27	24.3
Types of containers used for cold supply chain service			
10	Refrigerated containers	26	23.4
11	Insulated containers	35	31.5
12	Controlled atmosphere containers	34	30.6
13	Dry ice containers	16	14.4
Technology used for solution			
14	GPS	53	47.7
15	RFID	27	24.3
16	IOT	24	21.6
17	TELEMETICS	7	6.3

INTERPRETATION

From the above table (1.1) indicates that 59.5% of the respondents are from Coimbatore, 40.5% of the respondents have the 6-10 years of operation, 53.2% of the respondents have 6 -10 containers, 31.5% of the respondents have using insulated containers, 47.7% of the respondents are using **GPS** for the technological solution for operational efficiency.

ANOVA

HYPOTHESIS:

H0: There is no difference between supply chain operations & service responsiveness of the cold supply chain operators.

H1: There is difference between supply chain operations & service responsiveness of the cold supply chain operators

2.1 Descriptives

Numbers of containers used for cold supply chain services								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1-5 years	20	1.4	0.503	0.112	1.16	1.64	1	2
6-10 years	45	2	0.564	0.084	1.83	2.17	1	3
11-15 years	22	2.41	0.503	0.107	2.19	2.63	2	3
above 15 years	24	2.21	0.833	0.17	1.86	2.56	1	3
Total	111	2.02	0.687	0.065	1.89	2.15	1	3

2.2 ANOVA

Numbers of containers used for cold supply chain services					
	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	11.887	3	3.962	10.579	0
Within Groups	40.077	107	0.375		
Total	51.964	110			

INTERPRETATION

From the above table 2.2 shows the significance value of 0.00 is lesser than 0.05, so the null hypothesis is accepted. It is interpreted that There is no difference between years in operation and number of containers used for cold supply chain operations.

HYPOTHESIS:

H0: There is no difference between technology solution used for tracking & monitoring the cold supply chain operations

H1: There is difference technology solution used for tracking & monitoring the cold supply chain operations.

2.3 Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2	12	1	0	0	1	1	1	1
3	25	1.08	0.277	0.055	0.97	1.19	1	2
4	35	1.63	0.69	0.117	1.39	1.87	1	3
5	18	2.56	0.784	0.185	2.17	2.95	1	4
6	18	3.06	0.639	0.151	2.74	3.37	2	4
7	3	3.33	0.577	0.333	1.9	4.77	3	4
Total	111	1.86	0.968	0.092	1.68	2.05	1	4

ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	66.906	5	13.381	38.956	0
Within Groups	36.067	105	0.343		
Total	102.973	110			

INTERPRETATION

From the above table indicates 2.4 The significance value of 0.00 is lesser than 0.05, so the null hypothesis is rejected. It is interpreted that There is no difference between technology solution used for tracking & monitoring the cold supply chain operations.

FINDINGS OF THE STUDY

SIMPLE PERCENT ANALYSIS

- Majority of the respondents are from Coimbatore, constituting 59.5% .
- 40.5% of the operators have been operating in the business for 6-10 years.
- Majority of the operators utilize 6-10 containers (53.2%) for their operations.
- 31.5%, of the operators have using a Insulated containers for their operations.
- The majority of respondents utilize GPS technology (47.7%) for their technological solutions.

ANOVA

- Maximum 0.00 significant value is less than p value.so we reject the null hypothesis, hence There is no difference between years in operation and number of containers used for cold supply chain operations.
- Maximum 0.00 significant value is less than p value.so we reject the null hypothesis, hence There is no difference between technology solution used for tracking & monitoring the cold supply chain operations.

SUGGESTIONS

To ensure the effective utilization of these advanced technologies, it is essential to provide comprehensive training programs and resources to container operators. By equipping them with the necessary skills and knowledge, they can maximize the benefits derived from RFID and IoT technologies, leading to overall operational efficiency improvement. By implementing these recommendations, cold supply chain service providers can enhance their operational efficiency, resulting in improved service quality, cost reduction, and a competitive advantage in the market.

4. CONCLUSION

Differences in operational efficiency are evident among selected container operators, influenced by factors such as technology adoption, infrastructure quality, and collaborative efforts. Those container companies that embrace advanced technologies like IoT monitoring and data analytics tend to achieve better efficiency through features such as real-time tracking, temperature control, and predictive maintenance. Additionally, companies with upgraded facilities and well-maintained fleets tend to perform better, emphasizing the importance of investing in infrastructure and fleet management. Collaborative partnerships across the supply chain play a crucial role in optimizing processes, utilizing resources effectively, and minimizing disruptions. To maintain and improve operational efficiency, it's essential to cultivate a culture of continuous improvement through investments in staff training, feedback mechanisms, and research and development initiatives. Furthermore, adherence to regulatory standards, especially in areas like food safety and temperature control, is essential for maintaining trust and credibility in the industry.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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