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A COST–BENEFIT ANALYSIS OF FREIGHT MODE SHIFT FROM AIR TO SEA: EVIDENCE FROM WIND POWER LTD.

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Keywords

Cost-benefit analysis, Air freight, Sea freight, Logistics optimization, Wind Power, Operational efficiency, Supply chain.

Abstract

This study conducts a cost-benefit analysis to assess the feasibility of switching from air freight to sea freight at Wind Power Ltd, focusing on optimizing logistics costs, lead time, and operational efficiency. The aim is to evaluate potential savings, identify key operational differences, and determine whether the transition would provide a sustainable, cost-effective alternative to air freight. Primary data was collected through surveys and interviews with 150 employees involved in logistics, procurement, and supply chain management. Secondary data from internal shipping records and industry reports supplemented this collection. The analysis compares transportation costs, delivery reliability, and customer satisfaction across both freight modes. The results reveal that while sea freight offers significant cost savings, it is associated with longer lead times and occasional service delays. The findings suggest that switching to sea freight could provide long-term cost efficiency, particularly for non-urgent shipments, but requires process adjustments to accommodate longer transit times.

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1. INTRODUCTION

The global supply chain is a complex web of interconnected logistics that requires companies to make strategic decisions about transportation modes. For Wind Power Ltd, a key player in the manufacturing of wind turbine components, transportation costs and lead times are crucial factors in maintaining competitive advantage. As the company manages a vast network of suppliers and customers across different regions, the choice of freight mode significantly impacts overall operational efficiency. Air freight has long been the preferred option due to its speed and reliability; however, it comes at a substantial cost. This research aims to explore the feasibility of transitioning from air freight to sea freight in an effort to reduce logistics expenses while maintaining timely product deliveries.

Switching from air freight to sea freight presents both opportunities and challenges. Sea freight offers a more cost-effective alternative, especially for bulk shipments, but it comes with the trade-off of longer transit times. The trade-off between cost savings and lead time flexibility is a critical decision point for companies like Wind Power. Additionally, fluctuations in fuel costs, trade policies, and environmental regulations further complicate the decision-making process. Understanding the financial implications of this shift is essential for making an informed decision that balances operational costs with customer satisfaction.

This study employs a cost-benefit analysis to evaluate the financial impact, operational efficiency, and overall effectiveness of switching from air freight to sea freight at Wind Power Ltd. By analysing transportation costs, lead times, and reliability metrics, this research seeks to provide actionable insights that could guide the company's logistics strategy moving forward. The findings are intended to inform key stakeholders about the potential long-term benefits of switching to sea freight, as well as the necessary adjustments required to accommodate the change.

2. STATEMENT OF THE PROBLEM

It faces significant challenges in managing its logistics costs and lead times, especially with the increasing demand for wind turbine components and global supply chain expansion. Currently, the company relies heavily on air freight for its shipments due to its speed and reliability. However, the high cost of air freight is becoming unsustainable in the face of rising fuel prices, environmental concerns, and the need to improve cost efficiency. The problem lies in determining whether switching to sea freight, a more cost-effective but slower alternative, can provide long-term savings without compromising delivery times or customer satisfaction. A comprehensive cost-benefit analysis is necessary to evaluate the trade-offs between cost reduction and operational efficiency, and to determine the viability of sea freight as a sustainable option for the company’s logistics strategy.

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3. REVIEW OF LITERATURE

Khan et al. (2023): Khan et al. examined critical risk factors in volumetric modular construction across Australia and New Zealand. Using surveys and fault tree analysis, they found design and planning risks were most significant. Key issues included design freeze delays, module geometry conflicts, and size/weight constraints. They emphasized addressing these risks to improve VMC adoption and sustainability.

Zhang & Liu (2021): Zhang and Liu evaluated cost-effective compliance options for ship operators in China's SECA. Their analysis focused on fuel switching and marine gas oil using data from a freight liner. Results showed fuel conversion was most economical under uncertain conditions. MGO offered better emission reductions, especially as the SECA expanded.

Fan, Gu, & Luo (2020): Fan and colleagues assessed compliance options for IMO 2020 sulfur regulations in China's SECA. They compared fuel switching with hybrid scrubbers using a cost-benefit framework. Fuel switching was more cost-effective under current market conditions. Scrubbers became preferable when SECA proportions increased or scrubber costs decreased.

Wang (2018): Wang explored how supply chain uncertainty affects logistics performance in Australia's courier industry. Using structural equation modelling, the study linked internal and external uncertainties to performance drops. Company-side uncertainties had the strongest negative impact. The study stressed managing uncertainty to improve logistics outcomes.

Sreedevi & Saranga (2017):This study investigated how environmental uncertainty drives supply chain operational risks in India. Using SEM and IMSS data, the authors examined flexibility as a mitigating factor. Supply and manufacturing flexibility reduced related risks in uncertain environments. However, internal capabilities alone could not offset delivery risks in developing markets.

4. OBJECTIVES OF THE STUDY

1. To find out the current usage of air and sea freight.
2. To compare the costs and delivery times of air freight and sea freight.
3. To check the reliability and risks of both freight modes.
4. To find switching to sea freight is practical and supports company goals.

5. RESEARCH METHODOLOGY

The study follows a descriptive research design and relies on primary data collected through Simple random sampling. The sampling universe for this research comprises employees from different departments related to logistics, including supply chain management, procurement, transportation, and warehouse operations. Additionally, external stakeholders such as freight forwarding agents, customs consultants, and transport service providers will be included in the sample. The sample size for the study is 150 respondents.

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Data Analysis Tools:

- PERCENTAGE ANALYSIS
- ANOVA (Analysis of Variance)
- Chi-Square Test

DATA ANALYSIS

TABLE 1: PERCENTAGE ANALYSIS

Variables	Particulars	Frequency	Percent
Department	Production	13	8.7
	Quality	9	6.0
	Supply chain manager	32	21.3
	warehouse	29	19.3
	Tooling	17	11.3
	Shipping	20	13.3
	Finance	30	20.0
Designation	General manager	29	19.3
	Deputy general manager	11	7.3
	Assistant general manager	27	18.0
	Manager	19	12.7
	Deputy manager	18	12.0
	Assistant manager	27	18.0
	Employee	19	12.7
Years of Experience in Logistics/Supply Chain	<1year	39	26.0
	1-3years	35	23.3
	3-5years	29	19.3

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	>5years	47	31.3
What is the current primary mode of tool import?	AirFreight	39	26.0
	Sea Freight	35	23.3
	Both	29	19.3
	Other	47	31.3
	Total	150	100.0
What percentage of tools are imported via air freight?	0-25%	40	26.7
	26-50%	31	20.7
	51-75%	35	23.3
	76-100%	44	29.3
To what extent do hidden/indirect costs affect total air freight expense?	Not at all	30	20.0
	Small extent	28	18.7
	Moderate	54	36.0
	Large extent	38	25.3
	Total	150	100.0

The distribution of respondents across departments reveals that 21.3% work as Supply Chain Managers, 20.0% are involved in Finance, and 19.3% are in Warehouse, 13.3% are in Shipping, 11.3% work in Tooling, 8.7% are in Production, and 6.0% work in Quality. Regarding designations, the distribution is as follows: 19.3% of respondents hold the position of General Manager, 18% are Assistant General Managers, 18% are Assistant Managers, 12.7% are Managers, 12.0% are Deputy Managers, and 12.7% are employees. Experience in logistics and supply chain is distributed as follows: 31.3% of respondents have more than 5 years of experience, 26% have less than 1 year of experience, 23.3% have 1-3 years of experience, and 19.3% have 3-5 years of experience.

The primary mode of tool import shows that 31.3% of respondents use other methods, 26% use air freight, 23.3% use sea freight, and 19.3% use both air and sea freight. Regarding the percentage of tools imported via air freight, 29.3% report that 76-100% of tools are imported this way, followed by 26.7% who report that 0-25% of tools are imported via air freight. The remaining respondents (23.3%) indicate that 51-75% of tools are imported via air freight, and 20.7% report 26-50%. When asked about the impact of hidden or indirect costs on air freight expenses, 36.0% of respondents stated that these costs have a moderate effect, 25.3% reported a large effect, 20.0% stated there was no effect, and 18.7% indicated a small effect.

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ANOVA

Relationship Between Demographic Variables and Key Factors for Effective Sea Freight Implementation

Null Hypothesis (H_0): Demographic variables have no significant impact on the critical factors for successful sea freight implementation.

Alternative Hypothesis (H_1): Demographic variables significantly impact the critical factors for successful sea freight implementation.

TABLE 2

Dimensions	Designation	N	Mean	SD	F	Sig
Department	Production	13	3.46	1.050	2.054	.062
	Quality	9	3.11	1.054		
	Supply chain manager	32	2.75	1.391		
	warehouse	29	3.34	1.203		
	Tooling	17	2.47	1.068		
	Shipping	20	2.50	1.100		
	Finance	30	3.13	1.306		
	Total	150	2.96	1.247		
Designation	General manager	29	3.24	1.123	1.262	.279
	Deputy general manager	11	3.27	1.104		
	Assitant genarl manager	27	2.85	1.322		
	Manager	19	3.37	1.257		
	Deputy manager	18	2.56	1.149		
	Assitant manager	27	2.74	1.259		
	Employee	19	2.79	1.398		
	Total	150	2.96	1.247		
Years of Experience in Logistics/Supply Chain	<1year	39	3.18	1.254	.740	.530
	1-3years	35	3.00	1.372		
	3-5years	29	2.76	1.244		
	>5years	47	2.87	1.154		
	Total	150	2.96	1.247		
What is the current primary mode of tool import?	AirFreight	39	3.18	1.254	.740	.530
	Sea Freight	35	3.00	1.372		

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	Both	29	2.76	1.244		
	Other	47	2.87	1.154		
	Total	150	2.96	1.247		

Interpretation:

The one-way ANOVA results indicate that respondents' department, designation, years of experience, and current mode of tool import do not significantly influence their perception of the critical factors for successful sea freight implementation. All variables show p-values above 0.05, confirming no meaningful differences among groups. Although minor variations in mean scores exist, they are not statistically significant. Therefore, the null hypothesis is accepted, suggesting that employees across different roles share a common and aligned view on the key factors needed for effective sea freight adoption.

CHI-SQUARE

To find Relationship between the Importance of Carbon Footprint in freight decisions and Mode with Lower Environmental Impact

Null Hypothesis (H_0):

There is no significant relationship between the importance of carbon footprint in freight decisions and the mode with lower environmental impact.

Alternative Hypothesis (H_1):

There is a significant relationship between the importance of carbon footprint in freight decisions and the mode with lower environmental impact.

S No	How important is carbon footprint in freight decisions?	Air Freight	Sea Freight	About the same	Not Sure	Total	Chi square value	df	pvalue	Chi square value
1	Very important	8	7	14	11	40	15.782[a]	9	.062	15.782[a]
2	Important	10	5	10	6	31				
3	Slightly important	7	10	15	3	35				
4	Not important	5	6	15	18	44				
Total		30	28	54	38	150				

Interpretation:

The results showed no statistically significant association between the importance of carbon footprint in freight decisions and the perception of which mode has lower environmental impact, χ^2 (9, N = 150) = 15.78, p = .062. This indicates that how important respondents consider carbon footprint does not significantly influence their perception of whether air freight, sea freight, or other modes have a lower environmental impact. Hence, null hypothesis (H_0) is accepted.

6. SUGGESTIONS

- Consider a phased transition from air freight to sea freight for non-urgent shipments to assess its impact on supply chain performance before fully committing to the switch. This allows for a risk-mitigated approach and operational adjustments.
- Optimize inventory management to accommodate longer lead times associated with sea freight. This includes improving forecasting accuracy and adopting just-in-time inventory strategies to reduce the need for emergency air freight shipments.
- Regularly monitor fuel price fluctuations, as they significantly affect both air and sea freight costs. Incorporating fuel price projections into cost models will help make more informed decisions regarding transportation mode selection.
- Consider the potential impact on customer satisfaction due to longer delivery times with sea freight. Work with customers to set realistic expectations regarding delivery timelines and prioritize air freight for high-priority shipments.
- Sea freight is generally more environmentally friendly than air freight. Consider incorporating sustainability goals into the decision-making process, as shifting to sea freight may align with broader corporate social responsibility (CSR) objectives.
- Develop a risk management strategy to address potential disruptions in sea freight, such as port congestion, weather-related delays, or labor strikes. Establish contingency plans for these risks to minimize service disruptions.
- Consider using a hybrid approach that combines both air and sea freight for different segments of the supply chain, ensuring that critical components or high-demand products are delivered via air freight, while other products can benefit from the cost savings of sea freight.
- Conduct a detailed long-term cost analysis to ensure that the initial savings from switching to sea freight are sustainable. Account for all associated costs, such as storage fees, handling costs, and potential delays, to get a holistic view of the cost- benefit impact.
- Leverage logistics management software to track and optimize both air and sea freight shipments. This will help identify inefficiencies, provide real-time data on shipment statuses, and enhance decision-making for optimal freight mode selection.

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- Engage with freight forwarding partners to explore potential cost-saving opportunities, such as negotiating better rates for sea freight or leveraging economies of scale, which can help reduce the overall cost of transportation.

7. CONCLUSION

In conclusion, the cost-benefit analysis of switching from air freight to sea freight at Wind Power Ltd highlights a significant potential for cost savings, particularly for non-urgent shipments. While air freight offers speed and reliability, its high operational costs make it an unsustainable option in the long run, especially with increasing fuel prices and environmental concerns. Sea freight, though slower, presents a more cost-effective alternative that can contribute to substantial savings across high-volume, non-time-sensitive shipments. The key benefits of switching to sea freight include lower transportation costs, greater capacity for bulk shipping, and a reduction in carbon emissions, aligning with sustainability goals.

However, the shift to sea freight does come with challenges, primarily related to longer transit times and potential delays due to weather conditions, port congestion, or other logistical disruptions. These factors must be carefully managed through strategic planning, including better inventory management, risk mitigation strategies, and clear communication with customers about realistic delivery expectations. By incorporating flexible delivery schedules and optimizing supply chain processes, Wind Power Ltd can balance the operational trade-offs of switching to sea freight without compromising service quality or customer satisfaction.

Ultimately, the decision to transition from air freight to sea freight should be based on a thorough evaluation of long-term cost savings, operational efficiency, and market dynamics. While a full transition may not be suitable for all types of shipments, adopting a hybrid approach that uses sea freight for cost-effective shipments and air freight for urgent deliveries could provide a balanced and optimized solution. Continuous monitoring of freight performance, cost trends, and customer feedback will be essential to ensuring the sustainability and effectiveness of this logistics strategy.

8. AUTHOR(S) CONTRIBUTION

The writers affirm that they have no connections to, or engagement with, any group or body That provides financial or non-financial assistance for the topics or resources covered in this Manuscript.

9. CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, And/or publication of this article.

10. PLAGIARISM POLICY

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will\

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