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Selection of Transportation Modes and Shipping Routes From Indonesia to Central Asian Countries: A Case Study of a Cigarette Company

[1,*]Fitriah Dwi Mulyani, [2]I Nyoman Pujawan

[1,2]Institut Teknologi Sepuluh Nopember, Indonesia
Email: [1]mulyanifitriah@gmail.com
*Corresponding Author: Fitriah Dwi Mulyani (mulyanifitriah@gmail.com)

Abstract- One of the cigarette companies is trying to expand its market to Central Asian countries but faces challenges due to the geographical position of Central Asia which is surrounded by land. So, this study aims to identify the most efficient transportation mode and routing strategy for export shipments from Indonesia to Central Asia, along with a practical implementation plan for the selected mode. The research methodology uses Fuzzy Analytical Hierarchy Process (AHP) to determine the weight of criteria and sub-criteria and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) to rank alternatives based on their similarity to the ideal solution. Data was collected through interviews and questionnaires with logistics experts, focusing on reliability, speed, and cost. The results show that airfreight is the most reliable mode, ensuring timely delivery and high cargo security. However, it imposes a substantial financial burden, consuming nearly 80% of PT. X's total export logistics budget. The second ranked option, multimodal ocean + rail via China, offers a balance between cost efficiency and reliability, and the third option, multimodal ocean + truck, while flexible, suffers from longer lead times due to a lot of unpredictable factors such as higher risks of congestion and customs delays at Central Asian borders. To mitigate these expenses, the study proposes a dual-mode strategy that prioritize airfreight for high value, time sensitive shipments, while progressively shifting routine exports to multimodal ocean + rail through China's eastern corridor. This hybrid approach balances cost efficiency and operational reliability while maintaining service quality across diverse market demands.

Keywords: Export, Logistic Route, Mode Transportation, FAHP, FTOPSIS.

I. Introduction

The globalization of the tobacco industry has driven Indonesian manufacturers to expand into new markets, including the landlocked countries of Central Asia. A survey conducted in 2001 reported that the prevalence of smoking among men was exceptionally high, reaching 65.3% in Kazakhstan and 51.0% in Kyrgyzstan, while the rates among women were comparatively lower at 9.3% and 4.5%, respectively. In Uzbekistan, tobacco consumption was also notable, with 38.1% of men and 1.6% of women identified as active users. Despite the growing demand for tobacco products in this region, logistics remain a major challenge due to geographical isolation and limited access to seaports. Previous studies have highlighted numerous deficiencies in supporting the infrastructure for land transportation across Central Asia. These limitations have led PT. X to perceive airfreight as a safer and more reliable option for ensuring delivery performance. Nevertheless, the company recognizes that market demand in Central Asian countries remains relatively stable, which underscores the need for a more structured and comprehensive logistics planning process. Such planning is essential to reduce dependency on costly airfreight and to explore multimodal alternatives that balance efficiency, reliability, and financial sustainability. This study addresses the problem of selecting efficient transportation modes and routes for exports from Indonesia to Central Asia. In practice, PT. X has tended to rely primarily on managerial intuition and personal/vendor's experience when selecting transportation modes and logistics service providers. The absence of structured prioritization has led to conflicting interests between minimizing expenses and meeting service requirements, creating ambiguity in strategic priorities and an overemphasis on ease of shipment execution rather than long-term efficiency. To achieve this, the research applies a multi-criteria decision-making framework using Fuzzy Analytical Hierarchy Process (FAHP) to determine the weight of criteria and Fuzzy TOPSIS to rank alternatives. By analyzing airfreight and multimodal options (ocean + rail, ocean + truck), the study seeks to provide practical recommendations for companies facing similar challenges. The findings are expected to contribute both academically, by demonstrating the application of fuzzy-based decision methods in logistics, and practically, by offering strategies to reduce costs while maintaining service reliability.

II. Literature review

2.1 Mode Transportation

Logistics processes within a company involve considerable costs, particularly in the tobacco industry where shipper covers procurement, allocation, storage, sales, and distribution. Logistics therefore plays a vital role in strengthening the link between export performance and economic growth (Jiang W, 2025). Logistic distribution planning has become increasingly complex due to the growing number of customers, diverse geographic markets, demand uncertainty, and competitive pressure to reduce operational expenses. Within this context, the choice of transportation mode represents a major challenge, as transportation is an essential component of the logistics system and directly influences efficiency, reliability, and sustainability in export operations (Alain Martel, 2016). Guélat (1990) defines transportation mode as a means of conveyance characterized by specific attributes, including vehicle type, carrying capacity, cost functions, and measurable lead times. The appropriate selection of transportation modes within a distribution logistics system is not only intended to optimize costs but also to enhance efficiency across multiple parameters such as delivery speed, service reliability, and operational flexibility. Transportation networks can generally be divided into three segments. The first is the initial stage, or pre-haul, often referred to as the "first mile," which involves product collection. The second stage is long-distance transit, typically containerized movement from door to door. The final stage, or "last mile," covers distribution to end destinations. Empirical studies indicate that pre-haul and last-mile operations are predominantly managed through road transport, whereas long-distance movements are undertaken using a combination of road, rail, air, and maritime modes (Udomwannakhet, 2018).

2.2 Fuzzy Analytical Hierarchy Process (FAHP)

The Fuzzy Analytical Hierarchy Process (F-AHP) was first introduced in 1996 as an enhancement of the conventional Analytical Hierarchy Process (AHP). The development of this method was motivated by the limitations of classical AHP in accurately addressing uncertainty within decision-making contexts. F-AHP provides a more robust framework by incorporating fuzzy set theory, thereby reducing the degree of imprecision that often arises from subjective judgments in traditional AHP. Through this integration, F-AHP improves the reliability and precision of decision outcomes, making it particularly suitable for complex problems where uncertainty and vagueness are inherent in the evaluation process.

2.3 Fuzzy TOPSIS

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), developed by Hwang and Yoon in 1981, is recognized as one of the most widely applied multi-criteria decision-making (MCDM) methods, second only to Saaty's Analytic Hierarchy Process (Hwang C., 1981). Its popularity stems from its methodological simplicity, ease of implementation, and applicability to problems involving multiple criteria and alternatives. The computational principle of TOPSIS is identifying the positive ideal solution (PIS) and negative ideal solution (NIS) and calculating the separation measures of each alternative from PIS and NIS to determine the relative closeness of each alternative to PIS (Tüysüz, 2020). In conventional TOPSIS, the weights and evaluations of criteria are assumed to be precisely known and represented using crisp numerical data. However, in practice, crisp data often fail to capture the uncertainty and ambiguity inherent in human judgment. Preferences expressed by decision-makers are frequently vague and cannot be articulated with exact numerical precision. To address this limitation, fuzzy set theory provides a suitable extension, enabling the representation of subjective preferences through linguistic variables. This integration enhances the robustness of TOPSIS in handling uncertainty and improves its applicability to complex decision-making environments.

II. Materials & Methods/ Methodology

This research adopts a quantitative methodological framework designed to evaluate transportation mode selection for cigarette exports from Indonesia to Central Asia. The study begins with the identification of key logistics challenges faced by PT. X, particularly the high reliance on airfreight and the need to explore multimodal alternatives. To address these issues, data were collected through structured interviews and questionnaires with logistics experts, company managers, and stakeholders. These instruments captured perceptions and evaluations of critical criteria such as cost efficiency, delivery speed with sub-criterias lead time and schedule frequency delivery, service reliability with sub-criterias delivery timeliness, cargo security, and historical operation performance.

The analytical process integrates two complementary multi-criteria decision-making techniques. First, the Fuzzy Analytical Hierarchy Process (F-AHP) is applied to determine the relative importance of each criterion and sub-criterion. By incorporating fuzzy set theory, F-AHP reduces uncertainty and subjectivity in expert judgments, producing more reliable weight distributions. Second, after calculating the weight of each criterias and sub-cirterias using FAHP, the Fuzzy TOPSIS method is employed to rank the available transportation alternatives. This technique calculates the relative closeness of each option to the positive ideal solution (best case) and the negative ideal solution (worst case), thereby generating a preference order among alternatives. The alternatives assessed in this study include airfreight, multimodal ocean + rail, and multimodal ocean + truck.

IV. Results & Discussion

The results of interviews with 5 experts confirmed the findings of the literature review, with all respondents agreeing that the six identified factors are critical to ensuring successful delivery, particularly in the context of exports from Indonesia to Central Asia. Several participants further emphasized the importance of additional criteria, such as the historical performance of shipping vendors, including both direct shipping liners and freight forwarders. As noted by (Lun, 2011), shippers today demand higher service quality than in the past, largely because they have greater access to alternatives and more comprehensive knowledge of logistics operations. The interview process served as the foundation for developing expert evaluation scales, which were subsequently distributed in the form of questionnaires. A total of 16 experts, representing the Asia export-import team, completed the assessment of criteria and sub-criteria.
Based on the overall weighting results derived from the Fuzzy AHP process, the ranking presented in Table 4.1 indicates that delivery timeliness reliability holds the most significant position and exerts the greatest influence in decision-making for transportation mode selection in cigarette exports from Indonesia to Central Asia. Conversely, cost emerges as the least prioritized factor. This finding diverges from the study of (Ndubi, 2016), which identified reliability as the third most important criterion after cost and product condition upon arrival. However, expert opinions at PT. X emphasize that delivery timeliness reliability is a critical determinant of supply chain efficiency. Enhancing reliability can be achieved through coordinated actions by shipping operators and the reduction of port congestion, whereas schedule uncertainty tends to increase operational costs. Timely delivery reduces warehouse storage duration and inventory expenses, while enabling more accurate planning of pick-up and distribution activities. This, in turn, minimizes risks of any additional cost like demurrage and charge-back fees, while safeguarding supply chain integrity through the smooth flow of product distribution.

Table 4. 1 Weight of Criteria and Sub-criteria

Criteria	Weight Criteria	Sub-Criteria	Weight Sub-Criteria	Weaight Multiply Criteria dan Sub-Criteria	*Rank*
Reliability	0,522	Delivery timeliness	0,449	0,235	1
		Cargo security	0,308	0,161	2
		Historical operation performance	0,122	0,064	5
		Historical performance of shipping vendors	0,121	0,063	6
Speed	0,261	Lead time	0,586	0,153	3
		Schedule frequency	0,414	0,108	4
Cost	0,217	Cost	0,217	0,047	7

The proposed methodology adopts a hybrid multi-stage process that requires normalized non-fuzzy weight inputs, as presented in Table 4.2, to serve as the foundation for subsequent decision-making analyses.

Table 4. 2 Normalized Weight

	Airfreight	Multimoda Ocean + Truck	Multimoda Ocean + Rail
Delivery timeliness	0,389; 0,451; 0,519	0,119; 0,188; 0,274	0,205; 0,169; 0,252
Cargo security	0,251; 0,299; 0,355	0,058; 0,090; 0,130	0,095; 0,111; 0,170
Historical operation performance	0,098; 0,116; 0,140	0,019; 0,029; 0,042	0,031; 0,031; 0,050
Historical performance of shipping vendors	0,100; 0,117; 0,139	0,015; 0,022; 0,030	0,023; 0,025; 0,039
Lead time	0,551; 0,587; 0,622	0,165; 0,236; 0,315	0,279; 0,208; 0,285
Schedule frequency	0,349; 0,384; 0,425	0,130; 0,184; 0,245	0,217; 0,103; 0,147
Cost	0,035; 0,051; 0,072	0,111; 0,144; 0,186	0,146; 0,111; 0,150

Table 4.3 illustrates the final step in the fuzzy TOPSIS procedure, which involves calculating the relative closeness of each alternative to the ideal solution, thereby generating performance scores. From this process, the highest-ranked alternative (rank 1) is identified as the optimal solution for implementation within the supply

chain system. This solution is expected to significantly mitigate risks, particularly those associated with the most critical criteria, as determined by the weighting results of the Fuzzy AHP analysis.

Table 4. 3 Rank Result of Fuzzy TOPSIS

Alternatives	d+	d-	Gap	*Rank*
Airfreight	0,293	1,576	0,157	**1**
Multimoda Ocean + Truck	0,970	0,720	0,519	**3**
Multimoda Ocean + Rail	0,949	0,728	0,508	**2**

According to the results of the fuzzy TOPSIS analysis, airfreight ranks first and is therefore identified as the optimal transportation mode based on expert evaluations. This is followed sequentially by multimodal transport combining ocean + rail and ocean + truck via the eastern corridor. Logistics and supply chain experts at PT. X noted that, at present, cost is considered the least influential factor in transportation mode selection. However, considering the company's future objectives and the procurement department's emphasis on service productivity, cost efficiency remains an important consideration. Table 4.4 presents a comparative analysis of the monthly expenses that PT. X would incur for cigarette shipments from Indonesia to Central Asian countries, thereby providing a quantitative basis for aligning operational decisions with long-term strategic goals.

Table 4. 4 Freight Cost Calculation Simulation

Transportation Mode	Rute Alternatif	Cost (C) (USD)
Airfreight	Jakarta – Doha – Almaty/Bishkek/Tashkent	512.190
Multimoda (*ocean + rail*)	Route Timur : Jakarta – Sea port laut China (misalnya Ningbo, Shanghai) – Almaty/Bishkek/Tashkent	41.750
Multimoda (*ocean + truck*)	Route Timur New Silk Road : Jakarta – China – Almaty	36.750

Based on the calculations presented in Table 4.4, the big difference between freight cost of airfreight and multimode transportation can be a basis for the company to dual transportation modes rather than relying exclusively on airfreight. This perspective is supported by (Ali Zahedi, 2021) , who argues that employing multiple modes of transport for the same destination can enhance service quality and increase overall supply chain profitability. In this context, the multimodal ocean + rail option, ranked second in the fuzzy TOPSIS analysis, offers a detailed route configuration which is Jakarta – Ningbo/Shanghai – Xi'an – Lanzhou – Urumqi – Khorgos, with Khorgos serving as the principal inland port where rail or truck movements exit China and enter Kazakhstan. The Day Sales Inventory (DSI) for e-cigarettes from PT. X in Kazakhstan, one of the Central Asian countries with the highest sales, is approximately 24 days, indicating that it takes approximately 24 days to convert inventory into sales. Therefore, a shipping scenario can be created to fulfill the initial cigarette stock by airfreight, then next month's demand will use multimodal transportation (ocean + rail) using the eastern route as shown in Table 4.5.

Table 4. 5 Shipment planning

Moda Transportasi	Dec		Jan		Feb		Mar		Apr		May	
Airfreight	early	end	early	end (small volume)	early	end (small volume)	early	end (small volume)	early	end (small volume)	early	end (small volume)
Multimoda (*ocean + rail*)	early	end	early (for Feb)	end	early (for Mar)	end	early (for Apr)	end	early (for May)	end	early (for Jun)	end

V. Conclusion

This study demonstrates that the reliability of delivery timeliness is the most critical factor in selecting transportation modes for cigarette exports from Indonesia to Central Asia. Using Fuzzy AHP and Fuzzy TOPSIS, airfreight was identified as the optimal solution, followed by multimodal ocean + rail, and lastly ocean + truck. While airfreight ensures speed and reliability, its high cost requires companies to consider multimodal alternatives to balance efficiency and expenses. For practical application, PT. X is advised to diversify transportation strategies by combining airfreight with ocean + rail to reduce logistics costs while maintaining service quality.

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