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Strategic issue of outsourcing logistics processes involving dangerous materials: a decision support model for selecting the right logistics provider

This study examines the outsourcing of dangerous goods logistics. Its objective is to investigate the set of criteria that can be established in a decision-making situation where a company intends to outsource logistics processes related to dangerous goods. Based on the criteria framework, a potential decision-making process can be visualized, illustrating the possible decision paths through which optimal alternative can be selected. Through a structured review of the relevant literature, the risk factors associated with activities involving dangerous goods can be identified, providing the basis for the development of the decision criteria framework. This framework subsequently serves as the foundation for the service provider selection criteria system, through which a decision-making process can also be visualized.
Keywords: dangerous goods, dangerous materials, outsourcing, decision-supporting, logistics
JEL-codes: D21, L21, M10, R40, R41

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1. Introduction

The logistics processes associated with the handling and transportation of dangerous goods or materials constitute a domain characterized by elevated risk exposure and a pronounced requirement for specialized expertise. A wide range of risk sources must be systematically identified, assessed, and evaluated in order to ensure the safe and incident-free execution of logistics operations. When a material classified as dangerous enters a firm's material flow, the organization is required to implement specific technical, organizational and regulatory measures to ensure full compliance with the applicable dangerous materials framework.
In many cases, firms lack the appropriate infrastructure, technological capabilities, certified personnel or risk-bearing capacity necessary for the safe management of dangerous goods. Consequently, the outsourcing of dangerous goods logistics processes emerges as a viable strategic alternative. Such decisions are typically embedded in a boarder make-or-buy context and involve considerations related to regulatory compliance, liability allocation, operational risk exposure and transaction costs.
The primary objective of the paper is to develop a decision support model, operationalized through a decision tree-based framework, to assist firms in systematically identifying and evaluating the risks associated with specific dangerous goods logistics processes. The proposed model aims to support managerial decision-making by determining on a risk-informed basis, under which conditions the outsourcing of a given logistics activity is justified.
The outsourcing of dangerous goods logistics processes represents a critical decision context in which regulatory compliance and the maturity of risk management practices are of paramount importance. While numerous studies have examined the risk factors associated with dangerous goods, and the role of logistics service providers as distinct sources of risk has also been widely addressed, there is a lack of research that integrated these two domains into a unified analytical framework. The objective of this paper is to bridge this research gap by investigating the risks associated with dangerous goods logistics within a service outsourcing context. Based on prior research and expert judgment, the identified risks are systematically weighted, thereby enabling the development of a decision-support model grounded in a prioritized and relevant set of criteria. This model aims to assist companies in determining the key attributes, certifications, and

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infrastructure requirements that a logistics service provider must possess in order to ensure the safe and compliant handling of dangerous goods.

2. Literature review

The problem addressed in this study is inherently complex. The timeliness and relevance of the research are driven by the continuously increasing demand for the production and utilization of dangerous materials. In this context, the transportation, storage, and handling of such materials as dangerous goods constitute a significant logistics challenge, requiring strict adherence to an extensive and multifaceted regulatory framework. When combined with outsourcing considerations, this results in a highly complex decision-making scenario.

The literature review focuses on the conceptual and operational characteristics of logistics processes involving dangerous goods. In addition to outlining the structural features of dangerous goods logistics, this section reviews the relevant regulatory frameworks and synthesizes the risk factors identified in the extant literature.

2.1. Conceptual framework of dangerous goods and materials

Dangerous goods are defined as substances or materials that required heightened attention and specialized expertise throughout logistics operations, as improper handling may results in hazards to human health, property, safety or the environment (Güner-Özbek, 2008; Fattahi & Behnamian, 2021; Gholamizadeh et al., 2026). The integration of any dangerous material and goods into the supply chain necessitates comprehensive documentation ensuring its safe and compliant management across all stages of the logistics process.

A central document in this context is the Safety Data Sheet (SDS), which accompanies the material throughout the supply chain. The SDS provides detailed information regarding transportation, storage, handling and regulatory classification. It specifies the inherent hazards of the material or goods, potential sources of risk, prescribed risk mitigation measures, and the required emergency response protocols in the event of an incident (Mannan, 2012; Ho & Tenkate, 2024). While the SDS is traditionally paper based, the digitalization of compliance documentation has led to the widespread adoption of electronic SDS (Balázs-Kalázs & Rostás, 2026), thereby enhancing accessibility, traceability and integration into logistics information systems.

According to the logistics literature, core logistics processes may be conceptualized as loading, transportation and storage, complemented by ancillary activities such as packaging, warehousing, inbound storage, outbound handling, internal material handling, order picking, and dispatching (Sadjady, 2011; Gutiérrez et al., 2023). When dangerous goods or materials enter the material flow, the regulatory and operational requirements governing these processes are substantially modified. All logistics activities – including loading, transportation, storage, packaging, warehousing, inbound and outbound handling, material movement, order picking and dispatch – must be executed strictly in accordance with the specifications, hazard classifications, and handling instructions set forth in the applicable SDS and relevant regulatory provisions.

Given that dangerous materials logistics materials logistics necessitates dedicated risk management procedures, specialized infrastructure, certified personnel, and compliance assurance mechanisms, a growing number of logistics service providers have developed specific capabilities in this domain. Firms may opt for comprehensive dangerous materials logistics services, encompassing the full spectrum of activities, or alternatively outsource selected subprocesses to external providers. The following subsection examines the characteristics and risk profiles associated with individual logistics activities in the context of dangerous goods or materials.

2.2. Summary of risks associated with individual logistics activities

Logistics service providers may assume responsibility for the end-to-end management of supply chain activities, complex freight forwarding operations or selectively outsourced logistics subprocesses (Jharkharia & Shankar, 2007; Beckers et al., 2023; Abbasi et al., 2024). Within the conceptual framework of advanced logistics service models – up to the fifth-party logistics (5PL) configuration – it is necessary to identify and categorize the tasks and processes that constitute dangerous materials logistics (Hosie et al., 2012; Langley et al., 2016; McDonald & Ngo, 2025).
Figure 1 illustrates the structural positioning of dangerous goods-related activities within the multi-level logistics service provider model and serves as the basis for the subsequent risk-oriented process analysis.

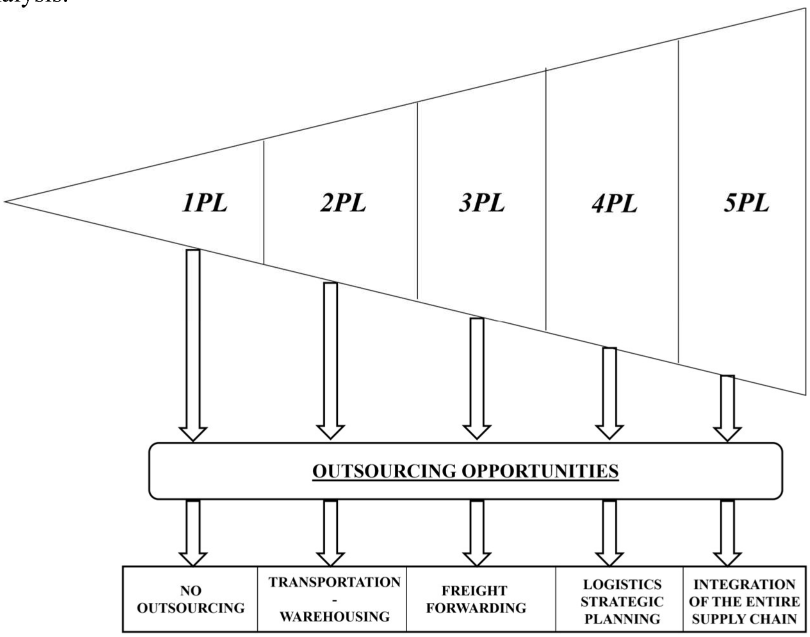

Figure 1: The outsourcing opportunities according to the 5PL model (source: own construction based on Hosie et al., 2012; Langley et al., 2016; McDonald & Ngo, 2025)

Figure 1. illustrates the 5PL model of logistics service providers, demonstrating the range and complexity of services that companies can offer to their client organizations. As depicted by the progressively expanding pyramid structure, higher PL levels correspond to an increasing breadth and integration of services provided by the logistics operator, as well as a greater extent of service utilization by the contracting company.
At the first level of the logistics service structure, no outsourcing takes place; the firm performs logistics activities using its own assets and internal resources (it means, it is an in-house logistics).
At the second level, basic logistics functions – such as transportation and warehousing – are delegated to an external logistics service provider.
Building upon this, the third level encompasses not only transportation and storage but also complex freight forwarding and coordination activities. At this stage, the service provider assumes significant organizational and planning responsibilities. In many cases, the provider does not directly perform the physical carriage but subcontracts transportation tasks to specialized carriers, thereby acting as an integrative coordinator within the logistics network.
The fourth level further extends these capabilities by incorporating advanced information technology support and supply chain-level strategic planning.

At the apex of the logistics service hierarchy, the provider assumes responsibility for the integration of the entire supply chain, effectively achieving a form of virtual integration of the entire supply chain, effectively achieving a form of virtual integration (Langley et al., 2016; Nicoletti & Appoloni, 2024).

The 5PL framework is equally applicable to logistics service providers specializing in dangerous materials or goods. On this basis, the subsequent analysis identifies and evaluates the risks associated with individual dangerous goods related logistics activities.

In the context of transportation and carriage, a distinction must be made between different modes of transport. The harmonized classification system for dangerous goods in road transport is defined by the European Agreement concerning the International Carriage of Dangerous Goods by Road (in short ADR, but in originally Accord européen relative au transport international des marchandises Dangereuses par Route). Based on hazard identification criteria, the ADR categorizes dangerous goods into nine classes according to their primary risk characteristics (e. g. explosives, toxic substances). This classification framework is grounded in the intrinsic hazard properties of the material (UNECE, 2026a; Lukács & Veres, 2024).

In accordance with this classification system, standardized hazard labels (placards) have been develpod to visually communicate the nature of the risk. These consist of a square set on its vertex (diamond shape), featuring a background colour corresponding to the hazard class, a central hazard symbol, and the class number displayed in the lower corner. Such labels must be affixed to the packaging, while enlarged placards – where prescribed by the ADR – must also be displayed on vehicles and transport units in designated positions (DOT Chart, 2026; EUR Lex, 2026).

Dangerous goods and materials are further identified by four-digit UN number. In addition, certain substances are assigned two- or three-digit hazard identification numbers, sometimes preceded by the letter ‘X’, indicating specific risk characteristics. Vehicles transporting dangerous goods are required to display orange rectangular plates of prescribed dimensions, typically positioned at the front and rear of the vehicle, in accordance with ADR requirements. (UNECE, 2026b).

These plates may be blank, indicating the carriage of packaged dangerous goods (less-than-tank or general cargo transport), or may display numerical codes arranged in two rows separated by a horizontal black line. The upper row contains a two-digit hazard identification number indicating the primary and subsidiary risks of the goods or material, while the lower row displays the four-digit UN number identifying the specific material. Numbered orange plates are required in the case of tank transport, bulk transport, and exclusive carriage of packaged radioactive materials.

Hazard labels, placards and orange plates are applied in both road and rail transport. In maritime or waterway transport, the same hazard classes are recognized; however, marking and placarding requirements are subject to mode-specific technical standards (Carosso et al., 2012). Rail transport of dangerous goods or material is governed by the Regulations concerning the International Carriage of Dangerous Goods by Rail (in short RID, in originally Règlement concernant le transport international ferroviaire de marchandises dagereuses). Maritime transport by the International Maritime Dangerous Goods Code (in short IMDG Code). The inland waterway transport in Europe regulated by the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (in short AND, in originally Accord européen relatif au transport international des marchandises dangereuses par voies de navigation intérieures).

Air transport of dangerous goods or materials represents a comparatively smaller volume due to stringent regulatory constraints and only materials or goods meeting specific criteria are permitted for carriage by air. The applicable regulatory framework is defined by the IATA Dangerous Goods Regulations (in short IATA DGR). IATA is the International Air Transport Association, which is the trade association for the world’s airlines.

Beyond general hazard determinants, it is essential to identify mode-specific risk factors associated with each transport modality in the case of dangerous goods carriage.

Strict compliance with mode-specific regulatory frameworks significantly mitigates the risks associated with the transportation of a given dangerous good. Importantly, such regulatory adherence is not limited exclusively to the act of carriage itself. For instance, the ADR provides a comprehensive regulatory structure that governs the entire dangerous materials process, extending beyond transport to include classification, packaging, marking, documentation, loading, unloading and handling requirements. Accordingly, compliance with transport regulations should be interpreted not merely as authorization for carriage, but as an integrated compliance obligation applicable to the end-to-end logistics process.

The application of appropriate packaging – both terms of type and quality – constitutes a fundamental logistics principle, as it protects the goods from mechanical, chemical and environmental stress throughout logistics operations. In the context of dangerous goods, packaging must additionally meet certified performance standards aligned with the relevant hazard class and packing group, thereby serving as a primary risk containment mechanism.

Furthermore, the rolling stock, transport equipment and infrastructure associated with each mode of transport represent potential sources of risk. Vehicle condition, tank integrity, intermodal transfer points, terminal infrastructure and technological reliability may all contribute to operational vulnerability. Consequently, these elements must also be incorporated into a comprehensive risk assessment framework for dangerous material logistics (Erkut et al., 2007; Holeczek, 2019; Mejlingová & Pántya, 2021; Lukács & Veres, 2024).

In the case of warehousing, priority must be given to regulatory and technical requirements governing the storage of dangerous goods and materials. In warehousing operations, it is essential to determine – based on the chemical properties of the goods or material – the specific environmental conditions under which the material may be stored. This includes compliance with prescribed temperature ranges, humidity limits, ventilation requirements and, where applicable, explosion-proof or fire-resistant infrastructure standards.

Particular attention must be paid to incompatibility considerations. Substances, goods or materials that may react with one another must not be stored in proximity, nor even within the same storage compartment, if such co-location could trigger hazardous chemical interactions. (Cournoyer et al., 2005; ABS, 2025; Karkori & Olsen, 2025). Consequently, segregation rules and compatibility matrices constitue critical elements of dangerous materials warehouse management.

From a risk management perspective, systematic inspection of packaging integrity is likewise indispensable. In the regulatory and operational context, a distinction is drawn between single packaging and combination packaging. In the case of single packaging, the dangerous goods or material is in direct contact with the packaging material, which itself interfaces directly with the external environment. By contrast, the combination packaging involves placing the single packaging within an additional outer packaging unit – such as a box or crate – thereby providing an additional layer of mechanical protection (Park et al., 2014). These solutions are typically applied in the case of packaged dangerous goods (less-than-bulk consignments).

Where the intrinsic properties of the material preclude the us of either single or combination packaging, Intermediate Bulk Containers (IBSs) must be employed. IBCs are predominantly used for liquid and bulk dangerous materials and serve as standardized containment units designed to ensure structural stability, leak prevention and safe handling within logistics operations (Lüttgens et al., 2005).

When engaging complex freight forwarding services or higher-tier logistics service models (e. g. 3PL or 5PL configurations), the service provider itself increasingly constitutes a distinct risk factor. At elevated levels of outsourcing intensity, the focal firm becomes progressively dependent of the provider's regulatory compliance capability, risk management maturity, information systems reliability, and governance structures. Consequently, the provider's organizational competence, certification portfolio, subcontracting practices and liability management mechanisms must be incorporated into the overall risk assessment framework (Figure 2).

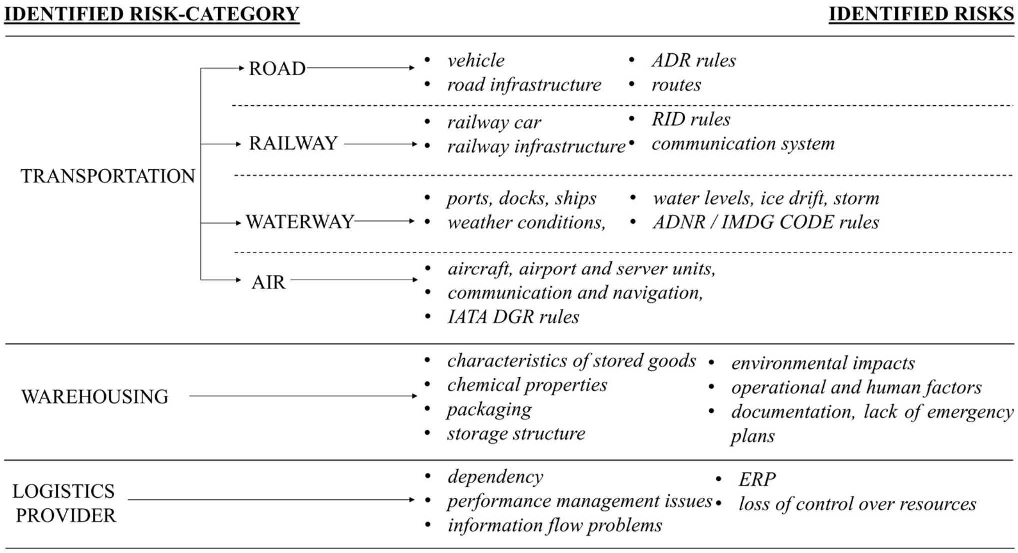

Figure 2: Summary of the identified risks (source: own construction based on the literature)

Figure 2. provides a structured overview of risk categories, followed by the identification of specific risk factors within each category. Accordingly, transportation and warehousing – representing the core logistics processes – are highlighted, alongside the logistics service provider as a primary source of risk. A more detailed breakdown of these categories reveals that, in the case of transportation, the key risk factors are predominantly associated with the availability and compliance of mode-specific regulatory frameworks and certifications. For warehousing, risks are primarily linked to facility structure, packaging practices, and documentation procedures. In relation to the logistics service provider, significant risks arise from dependency relationships induced by the level of integration, as well as from disruption and inefficiencies in information flow.

Across the previously examined, lower-tier service levels, the logistics service provider itself consistently emerged as an identifiable risk factor. The dependency relationship inherent in outsourcing arrangements substantially influences the focal firm’s make-or-buy decision, particularly in the context of dangerous materials logistics. Beyond structural dependency, performance-related risks associated with the provider – namely, whether the service provider is capable of maintaining a consistently high level of operational excellence – carry considerable weight in managerial decision-making situations (Barata et al., 2024).

In addition to differentiation by transport mode, the risks arising during carriage may be generally identified on the basis of the intrinsic characteristics of the consignment, the provision of the transport service itself and human factors. A frequently observed source of disruption consists of administrative errors and deficiencies attributable to negligent handling, these are, in most cases, ultimately traceable to human factors within transport and logistics operations.

Beyond these aspects, packaging and its regulatory conformity may be defined as a general transport-related risk factor. In the context of dangerous goods logistics, packaging performance and compliance with applicable regulatory frameworks (e.g., ADR, UN approved packaging standards and modal-specific provisions) are of critical importance. In such cases, packaging does not merely serve to protect the goods from external environmental impacts; rather, it must also ensure the protection of the environment from the potentially hazardous effects of the goods or materials transported. This dual protective function is essential not only from an environmental risk mitigation perspective, but also with regard to occupational safety, public safety and asset protection considerations within the supply chain.

Based on the synthesized findings, the outsourcing of dangerous goods-related logistics activities to a logistics service provider represents a complex, multi-criteria decision problem. The overarching objective of this decision process is the minimization of provider-related and operational risks while ensuring regulatory compliance and supply chain continuity. The following section introduces the development of a structured decision criteria system designed to support firms in addressing the identified problem.

3. Method for developing the decision criteria system

The primary objective of the paper is to support corporate decision-makers in establishing an appropriate evaluation framework for outsourcing decisions. The analysis specifically focuses on the outsourcing of dangerous materials logistics processes and accordingly, develops a method applicable to decision-making among logistics service providers specialized in dangerous goods management.

3.1. Methodology

The study applies a case study methodology to stimulate a realistic decision-making situation. Given that the research question addresses a highly complex scenario characterized by multiple interdependent variables while concentrating on a specific decision context, the case study approach is methodology justified. This approach enables the simulation of real-world business conditions and facilitates the development of practice-oriented solutions (Gronhaug & Ghauri, 2016; Paparini et al., 2020; Correa et al., 2025).

A structured literature review provided a comprehensive understanding of dangerous materials logistics management and served as the conceptual foundation for constructing the case scenario. By synthesizing and comparing the identified risk sources, a structured criteria system supporting the outsourcing decision can be developed.

To visualize the proposed solution, the study constructs an adapted decision tree model based on the developed criteria system. Decision tree models allow for the structured representation of decision alternatives, conditional pathways and potential consequences (Mingers, 1989; Kalip et al., 2022). In the present study, the theoretical foundations of decision tree analysis are applied to model and visualize the outsourcing decision mechanism in a systematic and transparent manner.

In summary, the study integrates three methodological approaches, a structured literature review, a case study-based decision modelling framework.

3.2. Case description

The case involves a domestic small- and medium enterprise (SME) operating as a supplier within an international supply chain. A new raw material has been introduced into its procurement portfolio. This material qualifies as a dangerous good: sulfuric acid, which is classified under Class 8 of the ADR.

The company has acquired a new customer located in Portugal that requires sulfuric acid for PVC production. To fulfil this demand, the SME intends to procure the substance from a Hungarian sulfuric acid manufacturing facility, hold is in warehouse inventory (including a minimal safety stock buffer to mitigate demand fluctuation), organize and execute its transportation to the customer.

Although the firm has previously managed ad hoc procurement transactions involving dangerous materials, the newly established partnership implies a long-term contractual relationship. Consequently, the company faces a strategic decision: whether to internally develop the necessary capabilities for the transportation and storage of dangerous goods or to outsource the related logistics processes to an external service provider.

Preliminary cost calculations and managerial preferences indicate a predisposition toward outsourcing dangerous materials logistics activities. The firm aims to contract with a high-tier logistics service provider, potentially at an advanced service level – e. g., 3PL or 5PL). To support this objective, a structured partner selection criteria system must be developed.

3.3. Development of the criteria system

The structured literature review enables the identification of key risk factors associated with both dangerous materials logistics processes and logistics service providers. In designing the decision criteria system, it is essential not only to account for direct provider-related risks – such as compliance capability, operational reliability and governance structure – but also to incorporate indirect risks arising from transportation and warehousing activities; e. g., mode-specific risks, storage incompatibility, infrastructure adequacy.
In accordance with managerial preferences and strategic priorities, the identified criteria should be weighted to reflect their relative importance in the decision context. The resulting criteria system – together with their assigned weights – forms the foundation of the proposed decision tree-based evaluation model. The figure below shows the criteria system and their relative weights in a hierarchical structure. The highest weight in the figure is 15%, which will be at the top of the structure, followed by factors with a relative weight of 10% in the middle level, and criteria with a relative weight of 5% at the bottom of the structure (Figure 3).

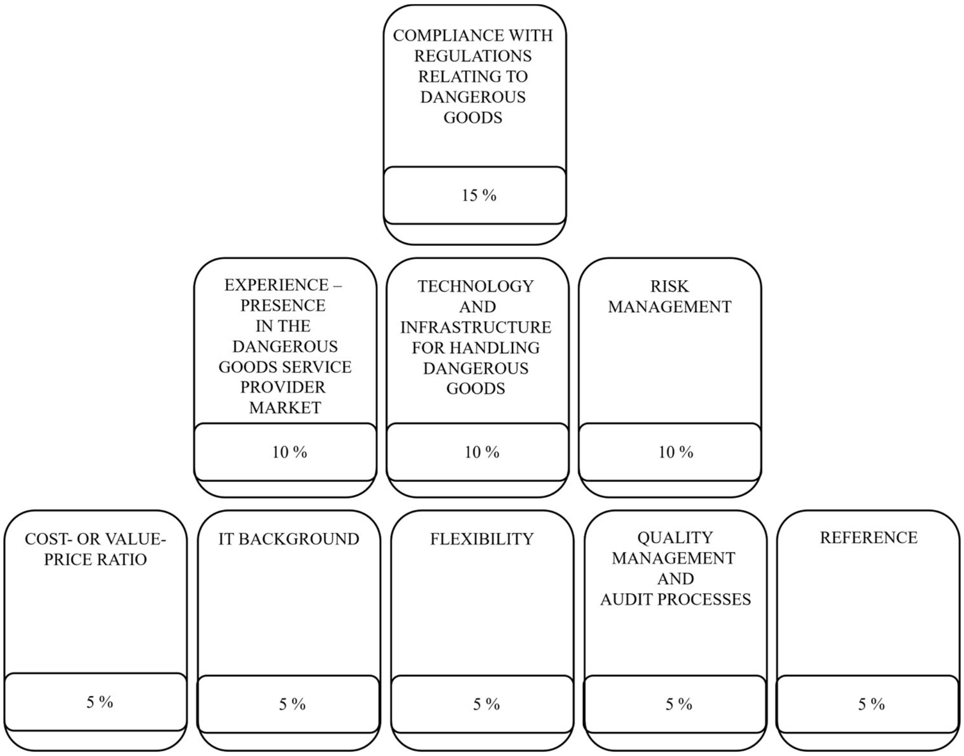

Figure 3: The criteria system (source: own construction)

In the determination of the weighting scheme, which is illustrated by the Figure 3, the researcher relied on findings and case studies identified in the relevant literature. Within these studies, expert judgement was frequently incorporated, for instance through the application of the Delphi method. Building upon the criteria established in the reviewed studies, and with particular emphasis on their underlying rationale, the evaluation criteria and their corresponding weights were further refined and developed. Overall, the existing literature demonstrates a clear trend toward the application of advanced MCDM techniques in dangerous materials logistics. The consistent use of criteria weighting, risk prioritization, and alternative ranking underscores the importance of structured decision-support tools in this high-stakes domain (Sattayaprasert et al., 2008; Ebrahimi & Tadic, 2018; Yilmaz & Verter, 2022; Kitthiphovanoth et al., 2026)

The developed criteria system was derived directly from the previously identified risk factors. The risk elements associated – either directly or indirectly – with dangerous materials and logistics service providers were systematically transformed into measurable compliance and performance criteria.

Regulatory compliance with international dangerous goods frameworks constitutes the most critical factor in provider selection. In the absence of demonstrable compliance capability, the selection of a given provider becomes untenable. Accordingly, the highest weight was assigned to this criterion, reflecting the objective of achieving the highest attainable level of regulatory conformity.

Beyond compliance, the availability of dedicated infrastructure specifically designed to support dangerous materials handling represents a key evaluation dimension. Market experience likewise functions as a proxy for operational reliability and accumulated expertise, therefore, longer market presence is associated with higher service maturity and correspondingly assigned a greater weight in the criteria system.

Given the inherently high-risk nature of dangerous materials logistics, the presence of structured risk management procedures is indispensable. Potential providers are expected to demonstrate standardized risk management methodologies, relevant certifications and documented control mechanisms. Additional – though relatively lower-weighted – criteria include the robustness of IT systems (supporting information flow and traceability), organizational flexibility in a dynamic economic environment, service pricing, the existence of formal auditing procedures and the strength of professional references.

Together, these elements constitute the comprehensive evaluation framework.

3.4. Modelling the decision process

In structuring the decision model, the overall objective – selection of the most appropriate dangerous materials logistics service provider – must first be defined. Subsequently, decision nodes are arranged according to the relative importance of the criteria.

The model distinguishes between three outcome categories, represented visually:

- *green* indicates the optimal solution;
- *yellow* denotes a conditionally acceptable alternative;
- *red* identifies an unsuitable provider.

The structured decision pathway facilitates the systematic identification of the most favourable alternative.

The first and most decisive criterion is regulatory compliance. This constitutes a primary screening factor in any outsourcing decision. If a provider lacks the necessary authorization to transport or handle the relevant dangerous goods, it must be immediately excluded.

It is essential to differentiate between transport mode-specific regulatory frameworks. In the present case, the primary modalities are road and rail transport. Therefore, compliance with the ADR for road transport and the RID for rail transport represent minimum eligibility requirements. Where a provider also holds certification for inland waterway or air transport, a broader service portfolio may be inferred. If a provider lacks ADR or RID compliance, it is deemed unsuitable (which means it goes to the red category). If it complies exclusively with ADR and RID, a limited but acceptable service scope may be assumed; which means this could be in the yellow path. Full multimodal regulatory compliance suggests a broader operational capability and position the provider within the optimal (green) category.

Only providers meeting at least ADR and RID requirements proceed to the next decision level, which concerns infrastructure adequacy. The absence of dedicated dangerous materials infrastructure constitutes a critical risk factor and results in immediate exclusion. The optimal scenario is one in which the provider maintains its own purpose-built infrastructure. Reliance on subcontracted infrastructure introduces additional risk exposure and therefore yields a conditionally acceptable classification.

At the subsequent level, experiential factors are evaluated. Extended market presence is interpreted as an indicator of operational maturity. A minimum threshold of five years' market activity may be established, while ten or more years of experience represents the target value and optimal condition. Providers with between five and ten years of experience fall into the acceptable category, albeit with elevated partnership risk relative to highly experienced competitors

Given the elevated risk profile of dangerous materials logistics, the existence of formalized and standardized risk management procedures constitutes another critical decision node. The optimal pathway requires documented, structured and standardized risk management systems. Partially developed or ad hoc procedures result in a conditionally acceptable classification due to increased operational uncertainty. The absence of any formal risk management framework renders the provider unsuitable.

On the basis of the above criteria hierarchy, the decision tree model can be constructed as illustrated in Figure 4, providing a transparent and logically structured representation of the outsourcing decision mechanism.

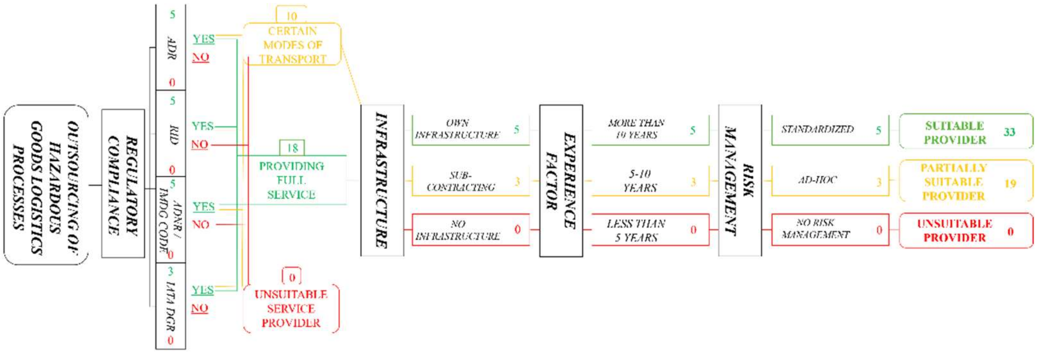

Figure 4: Provider selection model in terms of the outsourcing of dangerous goods and materials (source: own construction)

Due to space limitations, the model does not incorporate criteria assigned weights below 10%, instead, it focuses exclusively on the most significant evaluation dimensions. Consequently, the decision tree emphasizes the highest-weighted risk-derived criteria that exert the greatest influence on the outsourcing decision.

To ensure quantifiable and comparable outcomes, a simplified scoring system was incorporated into the decision tree. Given that regulatory compliance constitutes a fundamental prerequisite for logistics service providers handling dangerous goods, full compliance with the relevant legal frameworks was assigned a score of 5 points, while non-compliance was assigned 0 points. Considering that the transportation of dangerous goods by air is relatively infrequent, a lower score (3 points) was deemed acceptable in this modality. Based on this framework, a service provider may achieve a maximum of 18 points if it complies with regulatory requirements across all modes of transport. In cases where the provider holds authorization for at least one transport mode, it may be considered a partially acceptable alternative, corresponding to a score of 10 points. Conversely, if the provider lacks authorization for all transport nodes, it is excluded at this stage with a score of 0. Subsequently, the decision paths were evaluated using a color-coded scheme: green paths were assigned 5 points, yellow paths 3 points, and red paths 0 points. This approach yields a final, numerically comparable scoring outcome, whereby a fully compliant service provider attains 33 points, a partially suitable provider 19 points, a non-suitable provider 0 points. By applying the established scoring scheme in conjunction with the predefined weighting factors, the weighted average scores corresponding to each decision path endpoint can be calculated. The aggregation of these weighted scores is presented in Figure 5.

	TOTAL WEIGHTED POINTS	POINTS	WEIGHTS	CRITERIA
SUITABLE PROVIDER	**3.7**	18	15%	*REGULATORY COMPLIANCE*
		5	10%	*INFRASTRUCTURE*
		5	10%	*EXPERIENCE*
		5	10%	*RISK MANAGEMENT*
PARTIALLY SUITABLE PROVIDER	**2.4**	10	15%	*REGULATORY COMPLIANCE*
		3	10%	*INFRASTRUCTURE*
		3	10%	*EXPERIENCE*
		3	10%	*RISK MANAGEMENT*
UNSUITABLE PROVIDER	**0**	0	15%	*REGULATORY COMPLIANCE*
		0	10%	*INFRASTRUCTURE*
		0	10%	*EXPERIENCE*
		0	10%	*RISK MANAGEMENT*

Figure 5: Weighted scores achieved by the service providers. (source: own construction)

Figure 5 consolidates the information obtained throughout the evaluation process. Accordingly, within the proposed scoring framework applied in the case study, a potential logistics service provider must achieve a minimum weighted score of 2.4 in order to be considered a viable alternative in the decision-making process.

4. Conclusions and future research directions.

The developed decision model generates three possible outcomes, thereby classifying potential logistics service providers into three categories. Providers that satisfy all high-weight criteria – namely, full regulatory compliance for dangerous materials and goods handling, availability of dedicated infrastructure, extended market presence and the application of standardized risk management procedures aimed at minimizing logistics-related hazards – are categorized as suitable providers, which will be the optimal alternative.

Service providers that demonstrate partial compliance – such as limited multimodal certification, incomplete infrastructure necessitating subcontractor involvement, moderate market experience, and ad hoc or partially formalized risk management practices – are classified as partially or conditionally suitable providers. Although these firms may be capable of performing the required services, the associated orientational and dependency risk remain comparatively higher.

Naturally, real-world decision-making is not restricted to the linear pathways depicted in the model. The decision tree outlines optimistic, moderately optimistic and pessimistic trajectories based on the weighted scoring structure. The established criteria system forms the structural backbone of the provider selection framework, while the decision model represents one possible procedural pathway that decision-makers may follow. Through the application of weights, output values at each decision level can be determined, thereby enabling an objective and transparent basis for comparison among alternative providers.

As a direction for future research, the empirical testing of the proposed decision model within a specific corporate setting is recommended. Applying the weighted criteria framework in a real-world case would allow for validation of the model's practical applicability and robustness. To enhance the relevance of the criteria system and refine the weighting structure, the involvement of an expert panel is planned. A short online survey instrument is envisioned to validate and potentially extend the identified criteria. Subsequently, expert-based weighting of criteria – reflecting their perceived importance in dangerous materials logistics outsourcing decisions – would constitute the final step in the methodological refinement. Future research will target specialists from nationally operating companies engaged in dangerous goods logistics, thereby enabling empirical testing and further calibration of the developed decision model.

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