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A Theory-Derived Criteria Model for Evaluating Nordic Logistical Redundancy to the Suwalki Gap

ABSTRACT:
Denna studie adresserar avsaknaden av en teoribaserad kriteriemodell för utvärdering av militära försörjningskedjor i norra Europa. Mot bakgrund av Sveriges NATO-inträde analyseras alternativa logistiska korridorer för den militära försörjningen av Baltikum.
Nordisk militär rörlighet har historiskt prioriterat en syd-nordlig axel kopplad till försvaret av Nordkalotten. Det förändrade säkerhetspolitiska läget motiverar emellertid ett ökat fokus på den väst-östliga axeln för att minska sårbarheten kring Suwalki-korridoren och stärka den euroatlantiska länken.
Syftet är att utveckla och tillämpa en kriteriemodell baserad på teorier inom *Supply Chain Risk Management* (SCRM). Med Sveriges roll som transitland och värdlandsstödspartner som analytisk utgångspunkt, tillämpas modellen på tre rutter genom Skandinavien till en baltisk inskeppningshamn.
Resultatet visar att de analyserade nordiska korridorerna utgör genomförbara alternativ till Suwalki-korridoren. Samtidigt identifieras infrastrukturella brister och behov av förmågeutveckling som krävs för att säkerställa en fungerande och robust logistisk förbifart.

Keywords:
Supply Chain Risk Management, Criteria Model, Suwalki Gap, Nordic Reinforcement Corridors

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1. INTRODUCTION

This thesis addresses a significant gap in War Studies: the absence of a theory-driven criteria model to evaluate military mobility corridors for sustainment and reinforcement. The main contribution of this study is filling that deficiency by developing a novel Criteria Model for corridor assessment, derived from civilian Supply Chain Risk Management (SCRM) theory. This theoretical tool is necessary to analyse the real-world strategic problem of Suwalki Gap redundancy and identifying alternative logistics corridors. By testing the model through the analysis of real-life issue, this research delivers both a theory-derived tool and strategic insights.

The geostrategic significance of Lithuania is critical to the Baltic region, as it serves as a land bridge connecting the Baltic states to Poland and the Western NATO alliance via the narrow Suwalki Gap between Belarus and the Kaliningrad. Should an adversary seize the gap, it would physically cut-off the Baltic states from the rest of NATO, thereby complicating efforts to reinforce them.

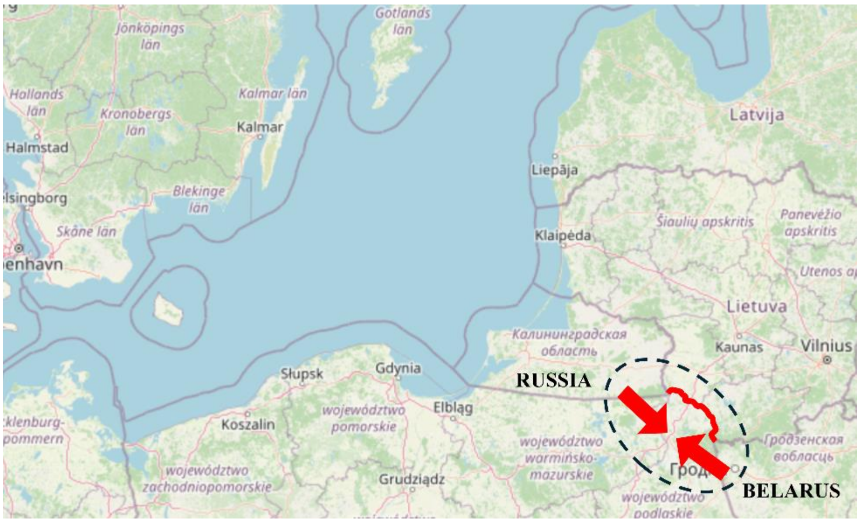

Figure 1: *Suwalki Gap (own work based on openstreetmap.org)*

Sweden's and Finland's NATO entrance has caused debate among military experts regarding its impact on the Suwalki Gap. Some experts argue that the Baltic Sea has become a "NATO lake" (National Defence, 2024). Conversely, some observers argue that the Baltic Sea is far from being a "NATO lake" and that significant challenges remain (Smirnov, 2023, p.51).

1.1. Research question. The ongoing debate regarding how Sweden's NATO membership has impacted the strategic importance of the Suwalki Gap, by offering potential alternative Nordic logistical routes, suggests a need for further scholarly research into this aspect. However, the viability of alternative corridors is uncertain. This uncertainty demands research into the current infrastructure and the deficiencies it holds. Moreover, there is a lack of a theory-derived, standardized evaluation tool – a Criteria Model – to systematically assess the viability and deficiencies of the logistical routes.

The research question:

“By applying the novel criteria model proposed in this thesis, how do the three identified Nordic logistical routes – Northern, Central, and Southern – compare, and what deficiencies persist even as Sweden’s NATO accession opens Nordic logistical redundancy for the Suwalki Gap?”

1.2. Research aim. The primary aim is to develop a theory-derived Criteria Model for evaluating the viability and deficiencies of logistics routes. The secondary aim is to empirically apply this model to comparatively rank the three proposed Nordic corridors.

1.3. Research gap. The primary deficiency is the lack of a Criteria Model derived from civilian scholarly theories for the military context. Furthermore, there is a lack of scholarly research analysing which Nordic infrastructure must be improved and which capabilities must be developed to utilize the new corridors.

1.4. Research contribution. The primary scientific contribution of this thesis is the development of a theory-derived Criteria Model specifically designed for evaluating military logistical supply routes. The secondary contribution is to evaluate the viability of alternative Nordic routes, providing insights for military planning.

1.5. Outline.

The thesis is structured to logically progress from the theoretical foundation to real-life military analysis. The Literature Review chapter emphasizes the long history of Supply Chains in War Studies. It presents the nearest state-of-the-art supply models to justify the necessity to develop a new Criteria Model. The chapter demonstrates the relevance of civilian SCRM concepts to the military context and affirms that these concepts require synthesis and adaptation to create the new model.

The Method chapter details the Mixed Methods Research approach, moving from the qualitative extraction of criteria to the quantitative application of the model. It justifies the scoring and weighting logic to ensure the study's results are replicable and scientifically robust.

The Theory chapter focuses on developing the Model. It systematically extracts relevant civilian Supply Chain risks from the SCRM literature and classifies them into a cohesive structure. This risk-based structure is then converted into the quantifiable Criteria Model, ready for application.

The Case Selection chapter identifies three alternative Nordic routes intended to sustain and reinforce the Baltics should the Suwalki Gap be denied.

The Analysis chapter applies the newly constructed model to test its validity and to examine the selected routes. The model and Multi-Criteria Decision Analysis (MCDA) are applied synergistically to quantitatively rank the routes.

The Discussion and Conclusions chapter reviews the outcomes of this thesis.

2. METHOD

2.1. Purpose and design. The research design of this thesis is a **Mixed Methods Research (MMR)** approach, rooted in the Pragmatism paradigm. The purpose is to bridge the identified research gap: the lack of a theory-derived model for evaluating military mobility corridors. By utilizing MMR, the study avoids a single-method limitation and instead uses a plurality of methods to provide both theoretical and empirical insights.

MMR is well-suited for the complexities of military logistics. Thaler argues that MMR enables researchers to understand complicated conflicts and provides empirical insights necessary to develop and improve theories (2017, p.59). Bleiker agrees that the world is too complex to be explained by a single method alone (2015, p.875). The MMR approach can be associated with the Pragmatism paradigm. Pragmatism avoids the traditional dualism of objectivity and subjectivity, instead using a plurality of methods suited to the specific research question (Kaushik and Walsh, 2019, pp.2–4).

Therefore, the study is designed in two phases.

2.2. Phase 1: Qualitative Model Development. The purpose is to develop a novel Criteria Model for evaluating military supply lines. This is achieved through **a qualitative analysis of academic literature** on civilian Supply Chain Risk Management (SCRM). The academic article analysis is a valuable method for synthesizing existing SCRM literature and identifying latent meanings within civilian concepts (Morgan, 2022, pp. 64–65). The design involves extracting, filtering, and synthesizing diverse civilian risks to create a unified, military-relevant analytical framework.

Identification and Derivation of Indicators. The indicators (sub-criteria) used in this study were identified through a systematic deductive derivation process in **three** stages. This ensures that the model is not based on intuitive metrics but is rooted in established SCRM theory.

First, theoretical extraction. The Distribution segment of the supply chain was identified as the most relevant area for military mobility. Using four SCRM classification theories (Rangel et al., 2015; Vilko & Hallikas, 2012; Hudnurkar et al., 2017; and Ho et al., 2015), a total of 97 civilian risks were extracted.

Second, filtering and synthesis. Civilian risks were filtered to keep only those relevant to the military context. These filtered risks were synthesized into six homogenous, military-centric dimensions.

Third, operationalization into Sub-Criteria. Synthesized risks were converted into measurable indicators. Example: the SCRM risk “lead-time” was operationalized into measurable indicator (sub-criteria) C9.1.Travel Time.

This structured derivation ensures validity, as every indicator in the model can be traced back to a specific risk identified in the academic SCRM literature.

2.3. Phase 2: Case Study (Quantitative). The primary purpose of the case study is to test the newly developed Criteria Model and to verify its analytical functionality. The secondary purpose is to empirically evaluate the viability of Nordic logistical redundancy for the Suwalki Gap. The design utilizes **a comparative approach within the case**. Three different Nordic reinforcement corridors (North, Centre, and South) have been selected as the testing-ground for the model not only due to its current geostrategic importance following Sweden's NATO accession, but also due to research suitability.

The three identified routes provide a high variety. The Northern route tests the model's ability to weight extreme weather and single-track vulnerabilities, while the Southern route tests its ability to evaluate dense infrastructure and urban congestion. Moreover, the model is designed to evaluate complex supply chains (sea-rail-road-air). The Nordic corridors require exactly this multimodal evaluation, making them a perfect stress test for the model's breadth. Furthermore, the model is built to provide a scientific basis for decision-making even when hard historical data is missing. The eastward Nordic routes are in an early stage of planning, which allows the model to show its value in structuring uncertain information.

By applying the quantitative MCDA Weighted-Sum Method (WSM), the study ranks these corridors based on the criteria established in Phase1. The research design of this phase is a single-case study with three sub-units of analysis, focusing on the Nordic region as a strategic logistical bypass. The primary purpose of the case study is twofold. First, to provide a "testing field" for the newly developed Criteria Model to verify its analytical functionality. Second, to empirically evaluate the viability of Nordic logistical redundancy for the Suwalki Gap.

WSM is a widely accepted approach for multi-objective optimization due to its ability to articulate non-complex preferences (Marler and Arora, 2010, pp. 853,861). However, WSM offers only linear estimates, and in some cases, more complex functions may be required (Marler and Arora, 2010, p.858). Furthermore, the selection of weights and preferences can be influenced by researcher bias. Since the objective is ranking logistical routes rather than mathematical optimization, the model does not require the unnecessary complexity of non-linear advanced methods.

Weighting rationale. Weights were established based on professional military judgment and the strategic context of reinforcing the Baltics. The strength of the developed Criteria Model is its flexibility. The weights are not intended to be static but are instead designed to be dynamic parameters that can be adjusted based on operational scenarios, different commanders' intent, and the security context.

Level1 weights were established using a subjective prioritization logic, where a sum of weights must equal 1.0. Critical enablers such as Resilience to Adversarial Threats and Supply Line Performance are assigned higher weights (0.20). Standard infrastructure capacities are weighted at an average of 0.10.

Level2 weights use the same subjective prioritization logic and the internal distribution method (all sub-weights equal 1.0). Those that involve high-impact disruptions (Kinetic Interdiction, 0.7) are prioritized over those with recoverable impacts (Covert Interdiction, 0.3). Within infrastructure and environmental categories, weights are assigned accordingly to favor throughput capacities, and resilience to single-point of failures and high-impact disruptions.

The use of researcher-led weighting is a reasonable method when the goal is to provide a "first-cut" model evaluation. Hereby, the study ensures model's reproducibility. While the weights in this thesis reflect a high-intensity conflict scenario, the model itself remains neutral. Future researchers can adjust these weights using methods, such as the Analytic Hierarchy Process or expert panels (Delphi method), to reduce bias.

WSM scoring logic. This study employs a standardized scoring scale of 0-50-100. This linear normalization method transforms disparate data into a unified numerical format. It is an **ordinal ranking** from the worst performance to the median and to the best (0-50-100), where the gap between observations (meters, tons, hours) is not significant. This scale is effective because it prioritizes comparing the routes against each other over measuring mathematical intervals.

2.4. Step-by-step analytical procedure. The whole analysis was conducted through a structured four-step process, moving from theoretical synthesis to empirical ranking.

Step1, development of the model. The qualitative analysis of civilian SCRM literature was used to identify, categorize, and translate risks into a military context. This resulted in the hierarchical model consisting of 9 main criteria and 44 sub-criteria, which serve as the analytical lens for the study.

Step2, data collection and route identification. Three different logistical corridors (North, Central, and South) were identified based on their multimodal capacity (sea-rail-road-air) to support NATO reinforcement. Data for each route was gathered from official authorities, including the Swedish *Trafikverket* and maps. This data covered technical specifications and geographical risk factors.

Step3, scoring. Each of the three routes was evaluated against the 44 sub-criteria using an ordinal three-point (0/50/100) scale to ensure consistency.

Step4, WSM calculation. For each route, the score of each sub-criterion was multiplied by its assigned weight. These were then aggregated into the main criteria scores, and finally into a total score for each corridor. The corridors were then ranked based on their total score to identify the most resilient sustainment and reinforcement alternative.

2.5. Method limitations. The use of MMR increases the risk of conceptual stretching (Thaler, 2017, p.67). Therefore, SCRM theory concepts are applied consistently across the qualitative and quantitative phases. A degree of subjectivity is present in the criteria weighting, which relied on the researcher's professional judgement rather than an external expert panel. Furthermore, WSM employs a linear estimation; it may not fully capture non-linear risks where a single failure could impact an entire corridor. A limitation of the 0/50/100 scoring logic is its ordinal nature, which prioritizes linear ranking over numerical precision. Finally, while a wargaming phase would have allowed further refinement of the model, it was excluded due to lack of space.

3. LITERATURE REVIEW

In this chapter the existing theories will be reviewed to demonstrate that although existing SCRM models are well-established and functional, they remain insufficient for the specific military analysis required for the Nordic-Baltic corridor. The outcomes of the literature review will justify the necessity to develop a novel model, which is the main contribution of this thesis.

3.1. History of Supply Chains in War Studies. The reinforcement corridors relate to the lines of communications (LOCs) concept. It was introduced by classic military theorist Antoine-Henri Jomini, who defined LOCs as the practical routes connecting different parts of the army throughout the area of operations (Jomini and Cocroft, 2007, p.74). Jomini also introduced the term Logistics as "practical art of moving armies." (2007, p.188).

Alfred Thayer Mahan later adapted the LOCs concept into the sea domain, naming them Sea Lines of Communications (SLOCs). Mahan praised SLOCs because, unlike land roads, maritime routes were considered easy and wide (1991, pp.144–145).

More recently, William Pagonis established the supply line as the central determinant of success in modern near-peer conflict (1992, pp.72,158). The Gulf War witnessed the fastest and largest logistical buildup since WWII, demonstrating that modern power projection and reinforcement require the ability to move enormous quantities of men and material across oceans (Pagonis and Cruikshank, 1992, p.7).

3.2. State-of-the-Art SCRM Models in War Studies.

Model 1. Takvam *et al.* formulated a Stochastic Mixed Integer Linear Program (MILP) to optimize the selection of Sea Ports of Debarkation (SPODs) and the allocation of vehicles for supplying destinations in the Nordic military theatre (2025, pp. 220-221).

The findings show that optimal SPOD selection is significantly influenced by correlated road closures, meaning the best SPOD choice varies based on season and the ratio of demand to distribution capacity (Takvam *et al.*, 2025, p.220). The model is highly relevant because it uses the complex MILP optimization tool to inform defence plans.

However, the MILP model is insufficient because it focuses narrowly on selecting the best SPODs and allocating vehicles, instead of evaluating the entire mobility corridor. Moreover, the model focuses exclusively on bad weather disruptions, failing to include critical risk categories like adversarial interdictions. Finally, the model is limited to road transport, as the rail option was dismissed.

Model 2. Ryczynski and Tubis developed a tactical risk assessment model for military fuel supply chains in peacekeeping operations, integrating Fuzzy Theory (2021, pp.1-2). The main finding is that a tactical risk assessment method integrating the Fuzzy System can reliably estimate risk and offer a practical contribution to improving the resilience of military fuel supply chains in high-risk environments (Ryczyński and Tubis, 2021, pp.20–21).

The model is relevant because it provides an example of supply chain risk assessment developed specifically for a military mission (ISAF). Additionally, the use of Fuzzy Theory supports thesis's assumption that quantitative evaluation can be conducted even when hard data is unavailable.
However, the model is adapted for tactical-level fuel supply chains. It fails to incorporate the complex multimodal network requirements central to evaluating an entire Nordic corridor.
Model 3. Medvediev *et al.* introduced a model utilizing fuzzy logic to manage risks in the Ukraine-Poland grain supply chain, focusing on improving delivery time by identifying uncertainties on new routes (2024, p.1). The model's relevance lies in its successful quantitative analysis of a multimodal international transport corridor without relying on hard historical data. However, even if developed during the Russo-Ukrainian war, the model addresses only commercial risks and lacks the capacity to rank alternative routes.
Conclusion. While these existing models provide important insights and methodological basis, none of them are directly adaptable for the scope of this study. Therefore, it is necessary to develop a novel model for alternative mobility corridor analysis.
3.3. Foundational Concepts of SCRM.
Since the current State-of-the-Art military supply models are insufficient for the Nordic corridor analysis, a broader theoretical base is necessary. Those civilian SCRM concepts will be analysed that can be adapted to construct a suitable model for a military mobility corridor evaluation.
Supply Chain (SC): the SC is defined as the network of entities involved in the flow of products, services, finances, and information (Mentzer *et al.*, 2001, p.4).
Supply chain management (SCM): SCM handles the flow of goods within a supply chain and is defined as the network coordination to move materials and goods among organisations and individuals (LeMay *et al.*, 2017, p.1446).
Supply chain risk (SCR) and Disruptions: SCR is defined as any risk to information, material, and product flow from suppliers to end-users (Peck, 2006, p.132). Disruptions are risks that temporarily halt SC operations and cause a more severe and acute threats (Bugert and Lasch, 2018, p.4).
Supply chain resilience (SCRES): SCRES is highly important and easily translated to the military context. Christopher and Peck define resilience as "the ability of a system to return to its original state or move to a new, more desirable state after being disturbed." (2004, p.2). Redundancy is a key element developing a resilient SC, requiring alternative options to mitigate the risk of single-point failures (Li, 2025, p.138).
Supply Chain Risk Management: SCRM is the central concept in this thesis, though there is no clear consensus on its scope or definition (Sodhi *et al.*, 2012, p.2). Norrman and Jansson define SCRM as the management of risks and uncertainties caused by logistics-related activities or resources (2004, p.436). Jüttner *et al.* emphasize that identifying and managing risks is essential for reducing overall supply chain

vulnerability (2003, p.201), while Goh *et al.* underline that the scope of SCRM is both within the supply chain and outside (2007, pp.164-165).

Conclusion: Civilian SCRM Concepts. The analysis of civilian SC theories reveals relevant concepts, including distribution, flow of goods, network redundancy, resilience, possible disruptions, and risk identification. They offer clear connection points to the military context. However, these theoretical concepts are insufficient for direct use in constructing a comprehensive Criteria Model to evaluate military logistical routes. Civilian SCRM prioritizes commercial profit, while the military prioritizes operational effectiveness. Furthermore, the existing SCRM framework does not include personnel movement, which is crucial in military reinforcement operations.

3.4. SCRM and corresponding military concepts.

NATO doctrines do not provide a formal definition of “supply chain” in the same way SCRM literature does. The corresponding military definition of a supply chain is best understood through the concept of the Joint Logistic Support Network (JLSN) and its functional components: Logistics and Movement.

Joint Logistic Support Network (JLSN) is the system of organizations, nodes, and procedures that delivers logistic support (NATO, 2025, p.26). The analysis of the three Nordic routes is essentially an assessment of alternative JLSN for deployment into the Baltics. The JLSN is the physical structure and flow of the supply chain.

Logistics is defined by NATO as the “planning, preparation, coordination and execution of the supply, movement, maintenance and services to support the full spectrum of operations, using military, civil and commercial resources” (2025, p.25). Logistics has an overarching management function of a supply chain.

Movement is defined as the “set of activities involved in the physical transfer of personnel and material as a military operation” (NATO 2025, p.LEX-6). Movement is the process of physical transport within a supply chain.

Conclusion. The comparison between military and SCRM concepts confirms that civilian frameworks are insufficient for direct use in constructing the comprehensive Criteria Model. Key military factors are either absent or minimized in the civilian frameworks. Consequently, adaptation and synthesis of the relevant civilian SCRM frameworks are necessary to operationalise these theoretical concepts into an analytical tool for defence planning.

4. THEORY: CONSTRUCTING THE CRITERIA MODEL

The previous literature review of existing military logistics models highlighted a gap in War Studies: the lack of a holistic model for evaluating multi-modal reinforcement corridors. State-of-the-art military models do not incorporate multi-dimensional risks. Therefore, this study adopts SCRM theories as its theoretical lens. By integrating SCRM risks into a military context, the study ensures the research is theoretically grounded and operationally relevant.

The method to construct a new model is built from the SCRM theory through a systematic process of operationalization. Thus, this study develops a Criteria Model that translates theoretical risks into measurable analytical indicators.

4.1. Method for constructing the Criteria Model. This process involves a systematic, five-step approach. **Firstly,** I will identify and select the Supply Chain segment most relevant to military sustainment and reinforcement. **Secondly**, I will analyze risk-classifying literature to extract the relevant SCRM risks. **Thirdly**, a summary of the extracted military-relevant risks will be proposed. **Fourthly**, these summarized civilian risks will be further synthesized to propose a final classification structure. **Lastly**, this proposed risk classification structure will be converted into the consolidated military supply and reinforcement Criteria Model.

The Criteria Model will be constructed using SCRM risks as its foundational basis. Risk identification is the beginning of the SCRM process (Hudnurkar *et al.*, 2017, p.185). Therefore, focusing on risk types and resulting risks enables a systematic analysis of what could go wrong in a military supply line and where the failures originate, aligning well with the thesis's objective of identifying viability and deficiencies.

4.2. Identifying the relevant segment of Supply Chain. SCRM theory typically divides a supply chain into three principal segments: Procurement, Manufacturing, and Distribution (Borgman and Rachan, 2009, p.63). The **Distribution segment** of the supply chain is specifically relevant for criteria identification in military contexts. Distribution addresses the physical transfer and flow of material along the routes. The functions of Procurement and Manufacturing are internal and upstream processes that fall outside the geographical and operational scope of assessing the physical viability of a supply line. Therefore, focusing on risk types within the Distribution part and downstream processes is the necessary step in this analysis, as this approach enables evaluating the movement, flow, and delivery challenges within the military supply line.

4.3. Risk classification theories. For the risk classification analysis, I have selected the four most comprehensive academic articles (theories) in modern literature that specifically aim to classify SCRM risks. Despite the lack of consensus on risk types and the absence of a single standard classification in the literature, academic research confirms that certain risk types are consistently repeated and common in supply chain settings (Rangel *et al.*, 2015, p.6868). By analyzing literature that already synthesizes and attempts to standardize risk types, I establish a proven foundation for the criteria model.

4.4. Summary of military-relevant SCRM risks. The analysis of SCRM risk classifications enabled to extract relevant risk types and resulting risks from those four academic articles, retaining only those elements pertinent to military supply and reinforcement lines (see Table 1). This filtering step adapts commercial theory to the adversarial military context. The analysis concentrates on risks within the Distribution and downstream processes.

Table 1. *Summary of extracted civilian risks (relevant to military contexts), as identified in SCRM risk classification literature*.

Researchers	Risk types	Resulting risks
Rangel *et al.* (2015)	External environment problems (natural, man-made, events)	External risks to the chain. Accidents, catastrophic events, disasters (fire, earthquake, volcano, flood, hurricane, tsunamis), extreme weather, property damage, severe consequences. Theft, maritime pirate attack, terrorist attacks, war, diseases. Regulatory risks. Narrow geography.
	Transport system problems (physical, logistics, transit time)	Physical risks to the flow of goods, movements. Inefficiencies in the transport infrastructure, behindhand transport and inventory infrastructure. Lack of contingency plans. Transit and travel time, problems with long supply lines, clearance at the port.
	Infrastructure problems	Risks concerning assets and infrastructure required for distribution of goods, distribution modes, mobile asset losses.
Vilko and Hallikas (2012)	Supply risks	Lack of intermodal/multimodal equipment Bottlenecks in the transportation routes Capacity problems in railroad traffic Problems with customs clearance Ro-Ro/Ropax-capacity
	Security risks	Organized crime, terrorism Outside interference Spying, espionage Ownership of the merchant fleet
	Environment risks	Dangerous objects, fire Natural forces (weather changes, storms, floods) Geographical position Long distances Fog in the shipping lane Ice conditions, slipperiness in wintertime
Hudnurkar *et al.* (2017)	Transportation	Disruption of transport network Complexity, length of transport network Multimodal transport, delays Transshipment, product damage
	External environment	Natural disasters, fire Acts of war, terrorism, pirate attacks, thefts

		Political instability implications Impacts of government regulations Implications of social unrest Cultural differences operating SC Diseases, epidemics
Ho *et al.* (2015)	Macro risks	Natural disaster War and terrorism Fire accidents
	Demand risks	Lead times
	Supply risks	Inability to handle volume Single supply sourcing Small supply base
	Transportation risks	Border crossings, change in transportation modes Lack of outbound effectiveness Transport providers' fragmentation No transport solution alternatives On-time/on-budget delivery Damages in transport Accidents in transportation Maritime pirate attack Remote highway theft Stress on crew, lack of training, long working Negligent maintenance Transportation breakdowns Supply chain complexity Port capacity and congestion, customs clearance Paperwork and scheduling Higher costs of transportation

Conclusion: civilian SCRM risks vary in detail and lack a single standard classification. Therefore, to convert these civilian SCRM risks into military criteria, a further step is required: to synthesize the extracted, diverse risks into a cohesive structure relevant to military supply and reinforcement lines. This synthesis step is necessary to achieve a homogeneous, proven foundation for constructing criteria and to propose a final, military-relevant risk type and resulting risks classification.

4.5. Synthesis of extracted SCRM risks.

The extracted and filtered risks were grouped into six homogenous, military-centric dimensions (clusters), thereby resolving the differences among researchers and establishing a unified, threat-centric structure suitable for the Criteria Model.

Table 2. *The synthesis of extracted risks into a cohesive structure (relevant to military reinforcement corridors). The proposed classification*.

Dimension (Homogenous Cluster)	Risk Type (The Cause)	Resulting risks (Specific Threats/Factors)
Transportation and Movement Risk	Transport system problems	Complex supply chain, extended transport distances, intermodal transport, inadequate transport and warehousing preparedness, absence of contingency planning, customs clearance process, change of transport modes, transfer of goods between vehicles

		or modes, international boundary passages, unreliable outbound logistics, numerous transport contractors, lack of transport options.
	Transportation risks	Transit and travel time delays, network failure, accidents in transport, damages in material and transport, substandard personnel performance, crew fatigue, disruptions due to assets' failure, increased transport pricing.
Infrastructure and Capacity Risk	Infrastructure problems	Dysfunctional critical infrastructure. Insufficient infrastructure support, durability, redundancy, dynamic network. Choke points, bottlenecks. Deficient national infrastructure
	Capacity constraints	Rail and road capacity problems, throughput restrictions, seaport/airport capacity, Ro-Ro/Ropax ship throughput volume and handling limitations, handling dangerous goods.
Adversarial and Security Risk	Security risks	Unauthorized external access, thefts, organized crime, the ownership of vehicles and merchant ships (reliability), diseases.
	Hostile threats	War acts, sabotage, terrorist attacks, maritime pirate attacks, spying, espionage.
Macro Risk	Socio-political risks	Legal/regulatory constraints on movement, political instability risks, movement interruptions from civil disorder.
Environmental Risk	Natural events, accidents and disaster risks	Fire, earthquakes, volcano, flood, hurricane, tsunamis, extreme weather, property damage, weather changes, storms, floods.
	Geographical Exposure Risk	Constrained geography, geographical position, long distances and supply lines.
Supply Chain Management Risk	Supply risks	Cultural differences cooperating, lack of multimodal means, volume limitations, single point of failure, dependence on few suppliers.
	Demand risk	Lead times, customer dispersion and complexity, poor relationship with customers.

In conclusion, the synthesis successfully transforms diverse, commercially-focused threats into a unified, threat-centric analytical framework. This final, cohesive structure resolves terminological inconsistencies present in the initial risk classification literature and is adapted to the Distribution part. Therefore, the newly synthesized structure is sufficient for conversion into the Criteria Model.

4.6. Consolidated Criteria Model.

The synthesized civilian Supply Chain Risks are labelled sequentially (SCR1, SCR2). These foundational risks are then converted into the high-level Criteria Dimension (C1., C2). Each major Criterion is subsequently divided into measurable sub-criteria (C1.1., C.1.2.). These sub-criteria are derived from SCRM risks, ensuring they cover the full spectrum of risk sources while being translated for the evaluation of military sustainment and reinforcement lines.

SCR1. Hostile threats – **C1**. Resilience to Adversarial Threats.

C1. Criterion derives from the SCRM hostile threats, external environment, and macro risks.

C1.1. Kinetic Interdiction Exposure.

C1.2. Covert Interdiction Vulnerability.

C1.3. Information and Cyber Vulnerability.

SCR2. Security risks – **C2**. Security and Protection Requirements.

C2. Criterion derives from SCRM security risks.

C2.1. Criminal and Unauthorized Access.

C2.2. Reliability of Contracted Transport Assets.

C2.3. Route Force Protection Density.

C2.4. Health and Contagion Protection.

C2.5. Information Security.

SCR3. Seaport Capacity Limitations – **C3**. Seaport Handling Capacity.

C3. Criterion derives from SCRM seaport capacity, congestion, and connectivity risks.

C3.1. Port Availability and Throughput Capacity.

C3.2. Berth Accessibility.

C3.3. Customs and Clearance Efficiency.

C3.4. RoRo/Ropax Handling Capacity.

C3.5. Heavy-Lift and Oversized Cargo Capacity.

C3.6. Marshaling Area Availability.

C3.7. Connectivity to Hinterland and Airport.

C3.8. Port Rail-Terminal Integration.

C3.9. Handling Explosives, Ammunition, Dangerous Goods (EAD).

SCR4. Rail Capacity Problems – **C4**. Rail Throughput Capacity.

C4. Criterion derives from SCRM rail capacity risks.

C4.1. Track Configuration (Double-Track).

C4.2. Axle Load Allowance.

C4.3. Clearance Restrictions.

C4.4. Terminal Availability and Capacity.

C4.5. Rail Wagons and Locomotives Availability.

SCR5. Road Capacity Problems – **C5**. Road Throughput Capacity.

C5. Criterion derives from SCRM road capacity risks.

C5.1. Highway Lane Density (Four-Lane).

C5.2. Weight and Dimension Limits.

C5.3. Choke Point Frequency.

C5.4. Mountain Pass Frequency/Severity.

C5.5. Urban/Congestion Bypass Availability.

C5.6. Border Crossing.

C5.7. Heavy Equipment Transporters (HETs) Availability.

SCR6. Airport Capacity Limitations – **C6**. Airport Capacity.

C6. Criterion derives from SCRM risk airport capacity risks.

C6.1. Runway Metrics.

C6.2. Forward Movement Integration.

SCR7. Infrastructure Problems – **C7**. Network Resilience and Redundancy.

C7. Criterion derives from SCRM infrastructure risks.

C7.1. Route Redundancy and Bypass Availability.

C7.2. Network Connectivity and Meshedness.

C7.3. Interoperability and Standardization.

C7.4. Sufficient Host Nation Support Access.

C7.5. Emergency and Interim Support Facilities.

SCR8. Environmental Risks – **C8**. Geographical and Environmental Exposure.

C8. Criterion derives from SCRM constrained geography and environmental risks.

C8.1. Severe Weather Susceptibility.

C8.2. Natural Disaster Exposure.

C8.3. Geographical Constraint Density (Terrain).

C8.4. Canalization and Redundancy Limitation.

SCR9. Complex Supply Chain – **C9**. Sustainment Line Performance and Efficiency.

C9. Criterion derives from SCRM complex supply chain risks.

C9.1. Travel Time.

C9.2. Travel Distance.

C9.3. Cost.

C9.4. Supply Line Complexity.

Individual criterion are described in Annex A.

Conclusion: this model is sufficient as a comprehensive analytical framework for military logistical route evaluation. The model is designed to be generalized across different operational scenarios and security contexts because its structure is derived from recognized SCRM principles.

5. CASE SELECTION: NORDIC REINFORCEMENT CORRIDORS TO KLAIPEDA

This section presents the selection of military reinforcement corridors across the Scandinavian Peninsula and the Baltic Sea, using Klaipeda port as the final destination. The selection establishes three geographically different and logistically relevant corridors, ensuring multimodal transport availability. These reinforcement corridors are utilized to test the validity and applicability of the newly created Criteria Model and to examine their viability as alternative routes, reducing reliance on the Suwalki Gap.

The three benchmark Western SPODs are Narvik, Trondheim, and Gothenburg (Takvam *et al.*, 2025, p. 230). In this study, Halmstad, rather than Gothenburg, is selected as the western SPOD for the southern route to avoid civilian congestion. The selected ports offer multimodal transport infrastructure and connectivity for onward movement eastward. Luleå, Oxelösund, and Oskarshamn were selected as the Eastern SPODs on the Swedish Baltic Sea coast due to their geographical correspondence with the Western SPODs. The main inland traffic mode is rail, while roads serve as the supporting mode for redundancy.

1. <u>Route North</u>: Narvik paired with Luleå.
   The Northern corridor, relying on the Malmbanan rail-line and the E10 road.
   Airports: Narvik/Harstad and Luleå.
2. <u>Route Centre</u>: Trondheim paired with Oxelösund.
   The inland corridor utilizes various rail links through Central Sweden, maximizing the use of Swedish interior.
   Rail: Trondheim-Ånge-Ockelbo-Avesta-Kolbäck-Oxelösund.
   Road: Trondheim-Sundsvall-Uppsala-Enköping-Kungsör-Katrineholm-Nyköping-Oxelösund.
   Airports: Trondheim and Skavsta.
3. <u>Route South</u>: Halmstad paired with Oskarshamn.
   The Southernmost corridor, characterized by high-volume infrastructure and proximity, crosses the densely populated region of Southern Sweden.
   Rail: Halmstad-Nässjö-Hultsfred-Berga-Oskarshamn.
   Road: Halmstad-Växjö-Oskarshamn.
   Airport: Halmstad.

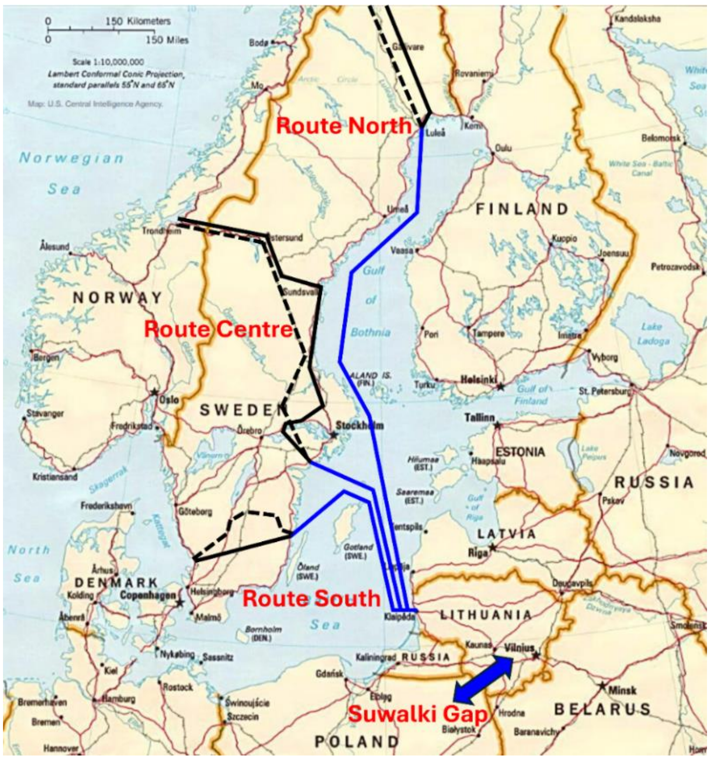

Figure 2: *Nordic Reinforcement Corridors to Klaipeda (own work based on geographicguide.com/europe-maps/baltic.htm).*

6. CASE ANALYSIS.

Having established the Criteria Model, the study now proceeds to the empirical phase. The following analysis serves as a validation of the developed model by applying it to three Nordic logistical corridors. This transition is operationalized through the four-step analytical procedure detailed in the method chapter, moving from data collection to the final ranking. Specifically, the 44 sub-criteria derived from SCRM theory are fed with empirical data gathered from official authorities and maps. The integration of these disparate data is achieved through the MCDA Weighted-Sum Method. Transition from theory to method is solidified by the use of MCDA WSM. This method allows for a systematic, numerical comparison of the routes based on the criteria derived from theory.

6.1. CRITERIA MODEL APPLICATION

This section applies the newly developed Criteria Model to evaluate the selected logistical routes and prepare the necessary data for the comparative MCDA ranking. The aim is to apply the relative criterion and sub-criterion to the respective routes. To ensure conciseness, only the weights assigned to the main criterion will be justified. The sub-criteria weights are assigned based on their importance to mission success. This process serves as a first-cut model application designed to verify the model’s functionality. Due to space constraints, the coding will not be explained. The analysis will be presented concisely, yet

sufficiently to illustrate the model's effective operation. The collected data, presented below, will be used in section 5.2. to determine performance scores and rank the routes.
This section provides very concentrated and concise data to feed the MCDA in the following section.
Resilience to adversarial threats criterion is weighted 0.2, higher than average. This heightened weighting is justified because kinetic interdiction by an adversary leads to personnel and material losses and can critically impact mission success.
Route North crosses the geographically isolated High North, featuring many single points of failure (SPOFs), making it susceptible to covert interdiction and high-impact disruption. The longest SLOC faces multiple chokepoints and areas of increased risks: passage through Åland, proximity to the Gulf of Finland, transit past the deep trench east of Gotland, and proximity to the A2AD zone of Kaliningrad.
Route Centre runs across the middle of the Nordic region. Its long inland segment and SPOFs make it susceptible to covert interdiction. The SLOC from Oxelösund is considered the most resilient to kinetic interdiction because of the shortest sea distance, the area is favorable to support escort operations and to ensure sea-control with military capabilities.
Route South crosses the best infrastructure network in southern Sweden, making it the least susceptible to SPOFs and possible sabotage. Its shortest inland segment increases avoidance and resilience. The SLOC is considered relatively more vulnerable to kinetic interdiction than Route Centre. This is due to the longer maritime distance, the necessity of passing the Kalmar strait and navigating around Gotland, and its proximity to the A2AD zone of Kaliningrad.
Security and protection requirements criterion is deemed not applicable in this analysis because its performance is assessed as equal across all three alternative routes.
Seaport handling capacity criterion is weighted 0.1, which is an average.
North: Narvik is a proven SPOD, fully adapted to reinforce the High North. It has no depth restrictions, good intermodal links, eight quays, Ro/Ro capacity, facilities for military, bulk, and container traffic; cranes 0-24 tons; it handles major iron-ore exports and offers a reception area of 33000m^2 with a requirement for 86000m^2 identified for port development, including expanded military reception capacity (TGS, n.d.).
Luleå is intended almost entirely toward bulk handling, making it a poor SPOD. Its depth is 11,6m; it features six quays and cranes 0-100 tons, limited container/Ro-Ro capacity, and inadequate marshalling area (TGS, n.d.).
A disbalance exists in the Route North: while Narvik is a proven SPOD, Luleå is a deficient SPOD, limiting the route's overall two-way capacity.
Centre: Trondheim is a proven SPOD, supported by the US Marine Corps Prepositioning Program. It features depths of 3-13m, fifty quays, intermodal links, cranes up to 100 tons, Ro/Ro capacity

(Trondheim Port Authority, n.d.). Oxelösund can accommodate the largest vessels due to its 16,5m depth; it features eleven quays, cranes up to 48 tons, intermodal links, Ro/Ro capacity (Oxelösunds Hamn, n.d.).
South: Halmstad serves as a central multimodal hub for southern Sweden, covering 830000m2 with 21000m2 of indoor warehousing and 25000m2 of paved stacking ground; it offers 2,4km of quay (6.5-11m depth), four Ro-Ro ramps, and cranes 8-160 tons; it handles annually 110000 cars, with planned investments for a 12m deep Ocean Port basin (TGS, n.d.). Oskarshamn is a smaller port, but versatile and effective: it features 441000m2 area, 44000m2 warehouse space, four quays (10,3m depth), three Ro-Ro ramps, and cranes 14-100 tons (Smålandshamnar, n.d.).
Rail Throughput Capacity criterion is weighted 0.1, which is an average.
Route North utilizes the *Malmbanan* railway, which connects Narvik with Luleå. This railway is a single-track line with passing loops but has the highest axle-load allowance in the Nordic region, rated at STAX-G (30 tons or 12 tons per meter) (Trafikverket, 2025).
Route Centre utilizes multiple railways: the *Mittbanan* (Trondheim to Ånge), *Norra stambanan* (to Storvik), *Godsstråket genom Bergslagen* (to Ängelsberg), and the line to Kolbäck and Oxelösund. This combined route consists of approximately 85% single-track and 15% double-track; it operates under a standard axle-load allowance, rated at STAX-D2 (22.5 or 6.4 tons per meter) (Trafikverket, 2025).
Route South utilizes multiple railways: the Halmstad-Nässjö line, *Bockabanan* (to Hultsfred), *Stångådalsbanan* (to Berga), and the connecting line to Oskarshamn. This route is a single-track line with passing loops, the majority of the route operates under the standard axle-load allowance, rated at STAX-D2, but approximately 15% of the route runs on the higher STAX-E4 rating (25 tons or 8 tons per meter) (Trafikverket, 2025).
Road Throughput Capacity criterion is weighted 0.1, which is an average.
Route North utilizes the *E10* road, which runs parallel to the *Malmbanan* railway. Road breadth varies between 6-8 meters; the structure consists of 2% four-lane, 12% three-lane, and 86% two-lane segments; it possesses the highest load-bearing class 4 and has no height obstacles up to 4.5 meters; the route includes 142 bridges and 3 tunnels, with the highest pass near Kiruna at 557 meters above sea level; there are very limited alternative routes to bypass civilian areas; there is one border crossing at Björnfjell customs (Trafikverket, n.d.), (Google Maps, n.d.-a).
Route Centre utilizes multiple roads: the *E14*, *E4*, *55*, *E18*, *56*, *52,* and *53*. Road breadth varies between 6-13 meters; the structure consists of 32% four-lane, 21% three-lane, and 47% two-lane segments; while the majority of the route (78%) possesses the highest load-bearing class (4), 16% is class 4 with special conditions, and 6% is class 1; there are no height obstacles up to 4.5 meters; the route includes approximately 550 bridges and 11 tunnels; a significant constraint is the steep incline and highest pass near Storlien at 620 meters above sea level; there are limited alternative routes to bypass civilian areas

(especially in the northern segment of the route); there is one border crossing at Storlien Customs (Trafikverket, n.d.), (Google Maps, n.d.-b).

Route South utilizes multiple roads: *25*, *37*, and *47*. The road is generally narrower, with breadth varying between 5-12 meters; the structure consists of 8% four-lane, 26% three-lane, and 66% two-lane segments; while almost the entire route (99%) possesses the highest load-bearing class (4), the road through Oskarshamn leading to the port is class 1; there are no height obstacles up to 4.5 meters; the route includes approximately 90 bridges and 0 tunnels, with no mountain passes; a major advantage is the availability of unlimited alternative routes to bypass civilian areas; no international border crossings (Trafikverket, n.d.), (Google Maps, n.d.-c).

Airport Capacity criterion is weighted 0.05, which is lower than average, because all military equipment must transit through the Nordics via land routes.

Route North airports: Harstad-Narvik (58,7km to SPOD by road) and Luleå (15,3km), with respective runway dimensions of 2800/45 and 3350/45 meters (Google Maps, n.d.-a). Both airports serve as bases for their respective national Air Forces.

Route Centre airports: Trondheim-Værnes (32,4km to SPOD by road) and Skavsta-Nyköping (22,6km), with respective runway dimensions of 2760/45 and 2880/45 meters (Google Maps, n.d.-b). Værnes airport serves as a base for Norwegian Air Force.

Route South airports: Halmstad (5,9km to SPOD by road) and Kalmar (75km), with respective runway dimensions of 2260/40 and 2050/45 meters (Google Maps, n.d.-c). The biggest disadvantage of this route is that Oskarshamn SPOD lacks a nearby airport.

Network Resilience criterion is weighted 0.15, higher than average. The effectiveness of a sustainment corridor is diminished if a single disruption can halt an entire reinforcement operation.

Route North relies on the *Malmbanan*, a single-track railway with no available rail alternatives. The E10 road is the only link from Narvik to Gällivare and a single option to pass the mountain. Redundancy improves south of Gällivare, where the E45 and road 97 through Boden offer an alternative bypass. Interoperability can be challenged by the border crossing at Björnfjell customs, involving potential technical, legal, and physical transition issues. Host Nation Support (HNS) capabilities can be provided by military bases in Narvik, Boden, and Luleå. The route possesses four hospitals and 16 rescue services (Google Maps, n.d.-a) (MSB, n.d.).

Route Centre relies solely on *Mittbanan* railway from Trondheim to Brunflo and the *E14* road to Östersund; single option to pass the mountain. Moving southeast, redundancy increases via the *Inlandsbanan*, *Norra Stambanan*, *Ostkustbanan* rail lines, and the *E45* road. Standardization issues can arise at the Storlien customs border and when transitioning across three military regions within Sweden. HNS is supported by military bases in Trondheim and Östersund, along with regional military assets. The route possesses eight hospitals and 39 rescue services (Google Maps, n.d.-b) (MSB, n.d.).

Route South features multiple rail and road bypass options and utilizes the densest road network. The only route that is not restricted by mountain passes. Standardization issues are minimal, only when transitioning across two military regions. HNS is ensured by the military base in Halmstad and supplemented by regional military assets. The corridor contains three hospitals and 14 rescue services (Google Maps, n.d.-c) (MSB, n.d.). It offers the highest overall density of support facilities in Sweden's most populated area.

Geographic Environmental Exposure criterion is weighted 0.1, which is an average.

Route North is assessed as having the highest environmental exposure due to extreme winter weather, snowstorms, and icy conditions. Natural disasters are possible (avalanches). The Björnfjell mountain pass and rough terrain in the High North constrain military mobility. These physical barriers canalize traffic into limited paths between Narvik and Luleå.

Route Centre experiences less extreme winter weather but remains vulnerable to road closures from snow and ice. This region suffers from floodings, which disrupt traffic (Abrahamzon, 2025). The Storlien pass presents a mountain bottleneck, and further geography constraints are critical when bypassing Stockholm and Lake Mälaren (infrastructure chokepoints: Hjulsta swing-bridge, Kvicksund lifting-bridge, Hallsberg railway juncture).

Route South is the least exposed to severe weather, geographical constraints, and canalizing terrain. Its flat topography and mild climate provide the most stable operational environment. However, the route faces a high-impact risk: a disaster in vicinity of Oskarshamn Nuclear Power Plant would have an enormous effect on the validity of the route.

Supply Line Performance criterion is weighted 0.2, higher than average. This criterion evaluates the full output of the entire logistical flow rather than focusing on individual infrastructure components.

Route North is characterized by moderate complexity, with a travel time of approximately 40 hours (theoretical, non-stop) and a total distance of 1700km (Google Maps, n.d.-a).

Route Centre presents the highest complexity. Although it offers shorter distance (1500km) and a faster travel time of 26 hours (Google Maps, n.d.-b) compared to the North, its efficiency is degraded by a high number of nodes.

Route South demonstrates minimum complexity and the highest efficiency: travel time approximately 18,5 hours, distance 800km (Google Maps, n.d.-c).

6.2. ROUTE MCDA APPLICATION

Ranking. The final ranking is determined by the total numerical score calculated for each alternative. This customized WSM ranking process comprises three steps. Firstly, weights were established for each Level1 criterion. The sum of Level1 weights must equal one. Subsequently, weights were assigned to the Level2 sub-criteria placed under each Level1 criterion. The sum of Level2 sub-criterion weights for a given Level1 criterion must also equal one. Secondly, performance scores are attached only at the Level2 sub-criterion to reflect how each route performs against the specific measure. A scoring scale from 0 (worst performance) to 100 (best performance) will be utilized. Score 50 will be assigned for a second-place alternative. Alternatives performing equally will receive equal scores. Any non-applicable criterion or sub-criterion will receive a score 0. This applies to the criteria that lack relevance to the Nordic corridors or due to unavailable information. Lastly, the total score is calculated by multiplying the Level1 weight, the Level2 weight, and the sub-criterion score. Summing all sub-criteria results will provide the total weighted score and the final ranking (highest score meaning the most preferred route).

Table 3. *Comparative Route Ranking using the MCDA Weighted-Sum Method*.

No./ Criteria/ Sub-criteria			Weight **L1**/L2	Route N Score	Route C Score	Route S Score
C1.	Resilience to Adversarial Threats		**0.2**			
	C1.1.	Kinetic Interdiction Exposure	0.7	0	100	50
	C1.2.	Covert Interdiction Vulnerability	0.3	0	50	100
	C1.3.	Info/Cyber Vulnerability	0.0			
			Score	**0**	**17**	**13**
C2.	Security/Protection Requirements		**0.0**			
	C2.1.	Criminal/Unauthorized Access				
	C2.2.	Reliability of Contracted Transport Assets				
	C2.3.	Route Force Protection Density				
	C2.4.	Health/Contagion Protection				
	C2.5.	Information Security				
			Score	**0**	**0**	**0**
C3.	Seaport Handling Capacity		**0.1**			
	C3.1.	Port Availability/Throughput	0.1	100	50	0
	C3.2.	Berth Accessibility	0.1	50	100	0
	C3.3.	Customs/Clearance Efficiency	0.0			
	C3.4.	RoRo Handling Capacity	0.2	0	50	100
	C3.5.	Heavy Lift/Oversized Cargo Capacity	0.1	0	50	100
	C3.6.	Marshaling Area Availability	0.2	0	50	100
	C3.7.	Proximity to Hinterland/Airport	0.1	50	100	0
	C3.8.	Port Rail-Terminal Integration	0.2	50	50	50
	C3.9.	Handling EAD	0.0			
			Score	**3**	**6**	**6**
C4.	Rail Throughput Capacity		**0.1**			
	C4.1.	Track Configuration (Double-Track)	0.5	0	100	0
	C4.2.	Axle Load Allowance	0.5	100	0	50
	C4.3.	Clearance Restrictions	0.0			
	C4.4.	Terminal Availability/Capacity	0.0			
	C4.5.	Rail Wagons/Locomotives Availability	0.0			
			Score	**5**	**5**	**2.5**
C5.	Road Throughput Capacity		**0.1**			
	C5.1.	Highway Lane Density (Four-Lane)	0.2	0	100	50
	C5.2.	Weight/Dimension Limits	0.2	100	0	50
	C5.3.	Choke Point Frequency	0.2	50	0	100

	C5.4.	Mountain Pass Frequency/Severity	0.2	50	0	100
	C5.5.	Urban/Congestion Bypass Availability	0.1	0	50	100
	C5.6.	Border Crossing	0.1	0	0	100
	C5.7.	Heavy Transporters Availability	0.0			
		Score		**4**	**2.5**	**8**
C6.	Airport Capacity		**0.05**			
	C6.1.	Runway Metrics	0.5	100	50	0
	C6.2.	Forward Movement Integration	0.5	50	100	0
		Score		**3.75**	**3.75**	**0**
C7.	Network Resilience/Redundancy		**0.15**			
	C7.1.	Route Redundancy/Bypass	0.2	0	50	100
	C7.2.	Network Connectivity/Meshedness	0.2	0	50	100
	C7.3.	Interoperability/Standardization	0.2	50	50	100
	C7.4.	Sufficient Host Nation Support Access	0.2	100	50	0
	C7.5.	Emergency/Interim Support Facilities	0.2	0	50	100
		Score		**4.5**	**7.5**	**12**
C8.	Geographic Environmental Exposure		**0.1**			
	C8.1.	Severe Weather	0.3	0	50	100
	C8.2.	Natural Disaster Exposure	0.3	0	50	100
	C8.3.	Geography Constraint	0.2	0	50	100
	C8.4.	Canalizing Terrain	0.2	50	0	100
		Score		**1**	**4**	**10**
C9.	Supply Line Performance/Efficiency		**0.2**			
	C9.1.	Travel Time	0.3	0	50	100
	C9.2.	Travel Distance	0.4	0	50	100
	C9.3.	Cost	0.0			
	C9.4.	Supply Line Complexity	0.3	50	0	100
		Score		**3**	**7**	**20**
		Total Score		**24.25**	**52.75**	**71.50**

Although the coding is not explained line-by-line, the scoring (0/50/100) is a logical extension of the empirical data detailed in the 5.1. chapter. Each score is mapped to specifications (distances, rail capacities). The table is a mathematical synthesis of the technical data discovered during the analysis phase.

Results. The comparative analysis demonstrates that Route South achieved the highest total score, establishing it as the most preferred reinforcement corridor. The newly developed Criteria Model, used in synergy with the MCDA WSM, identifies the southern corridor as the optimal choice to ensure reliable redundancy for the Suwalki Gap.

7. DISCUSSION AND CONCLUSIONS

The internal coherence of this study is built on logical progression from theory to results. The **Literature Review** first identified a gap in War Studies: the lack of a holistic model for evaluating multimodal reinforcement corridors. To fill this gap, **SCRM theory** was utilized to provide a scientific foundation for identifying risks. The **Method** then worked as a bridge to turn civilian risks into the 44 measurable indicators of the Criteria Model. Finally, the **Analysis** validated the model by applying the Multi-Criteria

Decision Analysis (MCDA) to three Nordic corridors. Ultimately, the study moves from a theoretical problem to a practical solution, identifying the Southern route as the most viable redundancy for the Suwalki Gap.

The developed Criteria Model achieves **face validity** by producing operationally reasonable and logical results. Model's effectiveness lies in its ability to translate qualitative theoretical risks into a structured quantitative framework. By deriving criteria from SCRM theory and applying them via MCDA, the model proves its value in quantitative ranking of reinforcement corridors and assessing their viability. The model and methodology are replicable and reproducible because they follow a systematic SCRM literature analysis and synthesis approach.

Connection to Previous Research and SCRM Theory.

This research and its findings prove that SCRM theory works effectively when used to analyze military mobility corridors. By identifying the Southern corridor as the most resilient alternative, the analysis validates the principle of "resilience through redundancy" as defined by Li (2025), which emphasizes that alternative options are essential to mitigate the risk of single-point failures. While foundational concepts in civilian SCRM often prioritize commercial profit, this study successfully adapts these principles to prioritize operational effectiveness in an adversarial military context.

Furthermore, the developed Criteria Model addresses the limitations identified in State-of-the-Art military models. Unlike the model by Takvam et al. (2025), which focuses narrowly on sea-ports and weather-related road closures, this study incorporates critical adversarial interdictions and evaluates the entire multimodal corridor. It also expands the tactical fuel supply chain assessments of Ryczyński and Tubis (2021) by incorporating the complex multimodal network requirements (sea-rail-road-air).

Finally, the study contributes to the SCRM risk classification literature by synthesizing the diverse risk types identified by Rangel et al. (2015), Vilko and Hallikas (2012), Hudnurkar et al. (2017), and Ho et al. (2015) into a cohesive military-centric structure. By mapping 97 civilian risks into 44 military sub-criteria, this research proves that civilian risk logic is relevant for structuring military uncertainty.

Reflection on the method.

The choice of a Mixed Methods Research design was a conscious decision to prioritize the development of a theory-derived model over a purely empirical or purely quantitative study. This approach enables bridging civilian SCRM theory and military application, ensuring that the criteria used are not intuitive but are derived from academic literature. A purely qualitative study, such as expert interviews, might have provided deeper nuances, but it would have lost the ability to produce a replicable, numerical ranking that can be used for decision-making.

Regarding the comparative case study, the selection of the Weighted-Sum Method represents a trade-off between complexity and utility. The linear WSM allows military planners to easily adjust weights based on changing contexts. By not choosing more advanced non-linear methods like Fuzzy TOPSIS or the Analytic Hierarchy Process, the study loses some mathematical granularity. However, this is a deliberate weakness, since the research objective is to provide a "first-cut" ranking. The unnecessary complexity of non-linear models would have obscured the model's goal of identifying broad adversarial, environmental and infrastructural redundancies. Consequently, while the 0/50/100 ordinal scale loses exact physical intervals, it has discriminatory abilities to clearly distinguish the Southern corridor as the most viable alternative for the Suwalki Gap. Furthermore, to improve the model and reduce bias, a formal expert panel should be used to assign weights.

Future research. Based on the findings and methodological limitations, several directions are proposed:

- Sophisticated MCDA methods, such as the Analytic Hierarchy Process or Fuzzy Topsis, should be employed to improve the model.
- Wargaming simulations would test the model's robustness by identifying critical and superfluous criteria, enabling iterative refinements to its overall structure.
- While this research focused on land-based infrastructure, future studies should concentrate on maritime routes and the sea-control challenge. Furthermore, alternative corridors, such as Trondheim-Sundsvall, Lysekil-Oxelösund, should be studied to broaden the perspective on regional redundancy.
- A classified version of this study employing Subject Matter Experts and utilizing sensitive data from national agencies would provide deep empirical insights. Researchers should conduct an in-depth assessment of specific capacities that were beyond this study.

Research question. The comparative evaluation conducted in this study proves that while all three proposed Nordic routes are viable alternatives to the Suwalki Gap, the Southern corridor is the most preferred. Its top ranking is based on superior network density, robust infrastructure, mild climate, and the shortest distance. Although the other two routes remain viable, they contain more limitations. Route North is geographically better suited to reinforcing Finland than for the Baltic States.

Although Sweden's NATO accession has successfully opened alternative corridors, the Baltic Sea has not, by default, become a "NATO lake", and several deficiencies persist. The following weaknesses have been identified:

- Nordic mobility South-North versus West-East: military mobility and infrastructure from west to east (across Scandinavia toward the Baltics) remain underdeveloped, as historical strategic focus has prioritized reinforcing the High North.
- Seaport Limitations: Luleå is currently unsuitable as an SPOD. Kapellskär is geographically advantageous, but it lacks multimodal capacity due to the absence of railway connection.
- Rail and Road Constraints: the *Inlandsbanan* requires full operational status for military mobility. Currently, the closure of the Mora-Kristenehamn segment forces to use more complex and vulnerable supply lines for Route Centre. Furthermore, Hjulsta swing-bridge, Kvicksund lifting-bridge, and the

Hallsberg rail juncture represent examples of significant SPOFs on important main supply routes (MSRs) that require mitigation.

- Strategic Chokepoints: the Stockholm and Lake Mälaren bypasses must be hardened to ensure MSRs' robustness. In the north, the *Malmbanan* requires double-tracking to reduce vulnerability to bad weather, industrial interference, and covert actions, as current redundancy is extremely vulnerable. In the south, segments of road 37 should be widened, and the road through Oskarshamn leading to the port should be hardened to class 4. Oskarshamn plays significant role reinforcing not only the Baltics, but also Gotland.
- Node-Specific Issues: the lack of an airport in Oskarshamn limits its capacity reinforcing the Baltics and Gotland. The proximity of the Oskarshamn Nuclear Power Plant raises concerns for Route South, suggesting that other corridors, such as Lysekil-Oxelösund/Nynäshamn, should be evaluated.

Finally, addressing these physical infrastructure gaps is not enough. The region must simultaneously develop HNS capabilities and enhance Sea-Control within the Baltic Sea to ensure security of these sustainment lines.

Societal and ethical implications. This research does not involve human subjects, interviews, or classified documentation. However, the ethical responsibility in this study is handling unclassified information. Even when utilizing open-source data, a researcher must ensure that the synthesis of information does not reveal sensitive details to an adversary. Therefore, this analysis maintains abstractness and cautiousness. Societal implication occurs when logistical corridors intersect with cultural objects and high-risk infrastructure. Karlskrona was excluded as a potential SPOD because the Naval Port of Karlskrona is a UNESCO World Heritage Site. Oskarshamn Nuclear Power Plant is located 20km from a designated SPOD. This societal implication necessitates protecting such sensitive infrastructure and surrounding population during military transit.

Scientific and professional relevance. This research bridges the gap between civilian SCRM theories and War Studies. While SCRM is well-established in the commercial sector, its systematic application to military reinforcement corridors remains limited. Traditional logistic assessments often rely on intuitive metrics, but this study develops a methodology for translating qualitative theoretical risks into quantitative parameters for military applications. War Studies has lacked this type of analytical model. The contribution of this thesis extends beyond the model itself and the empirical application. Developing this model required specific analysis and reasoning to synthesize literature from civilian logistics. While the comprehensive review of infrastructure is significant to demonstrate the model's functionality, the unique contribution to War Science is the analytical work established during the model's construction.

This research contributes to the Lithuanian Armed Forces by identifying viable alternatives to the existing Suwalki bottleneck. The study identifies the benefits, infrastructure limitations, and geographical vulnerabilities of these routes, offering new perspectives on strategic and operational military planning for crisis scenarios.

Declaration on the use of AI. The author used Google Gemini solely to refine grammatical structure and improve the readability and clarity of complex text segments. The author reviewed and edited the content and owns full responsibility for the content of this thesis.

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Annex A – Description of Criterion

SCR1. Hostile threats – **C1**. Resilience to Adversarial Threats.

C1. Criterion derives from the SCRM hostile threats, external environment, and macro risks. It addresses deliberate and hostile actions, which directly impact survivability and operational success.

C1.1. Kinetic Interdiction Exposure: Measures proximity and susceptibility to destruction of infrastructure and mobile assets by an adversary's fires (missile, air strike, drone, torpedo).

C1.2. Covert Interdiction Vulnerability: Measures the susceptibility of critical fixed sites and mobile assets to espionage, sabotage, terrorist attacks, hybrid warfare, maritime pirate attacks.

C1.3. Information and Cyber Vulnerability: Measures the protection and reliability of communication systems against cyber-attack.

SCR2. Security risks – **C2**. Security and Protection Requirements.

C2. Criterion derives from SCRM security risks. This criterion assesses the security challenges along the logistical route, covering intentional physical threats, the reliability of mobilized assets (reliability of owners/operators), and non-hostile risks to personnel.

C2.1. Criminal and Unauthorized Access: Measures the vulnerability to theft, organized crime, and unauthorized external access at vulnerable nodes (terminals, convoy support centers).

C2.2. Reliability of Contracted Transport Assets: Measures the risk of ownership (nationality), maintenance quality, and reliability of mobilized assets (vehicles, merchant ships).

C2.3. Route Force Protection Density: Measures the density of route segments requiring active military and other authorities' protection (escorts, patrols, checkpoints) due to security threats.

C2.4. Health and Contagion Protection: Measures personnel susceptibility to diseases and endemic health issues along the corridor, thereby reducing operational availability.

C2.5. Information Security: Measures the required level of security checks for third-party personnel and allows access to the entities of supply line, ensuring protection against infiltration.

SCR3. Seaport Capacity Limitations – **C3**. Seaport Handling Capacity.

C3. Criterion derives from SCRM seaport capacity, congestion, and connectivity risks. This criterion assesses the factors that limit the efficiency of SPOD, which is the gateway for military materiel.

C3.1. Port Availability and Throughput Capacity: Measures the maximum daily volume (tons/vehicles) the port can process with/without commercial traffic congestion.

C3.2. Berth Accessibility: Assesses the number of suitable deep-water berths for required vessels and the limits of the navigational channel (space, weather exposure).

C3.3. Customs and Clearance Efficiency: Measures the bureaucratic issues associated with customs clearance and documentation approval at the port.

C3.4. RoRo/Ropax Handling Capacity: Measures the capacity (ramps, piers, space) to handle volumes of Roll-on/Roll-off/Ropax vehicles and equipment.

C3.5. Heavy-Lift and Oversized Cargo Capacity: Measures the availability of heavy-lift cranes and equipment necessary to handle heavy and oversized military cargo.

C3.6. Marshaling Area Availability: Assesses staging space available for processing military assets before onward movement.

C3.7. Connectivity to Hinterland and Airport: Assesses the availability and proximity connecting to the road/rail network and airways; evaluates the chokepoint risk at the transition to multimodal routes.

C3.8. Port Rail-Terminal Integration: Assesses the availability and capacity of the on-site rail terminal, ensuring flow to the main rail corridor.

C3.9. Handling Explosives, Ammunition, Dangerous Goods (EAD): measures the port's dedicated infrastructure and compliance for legally handling EAD.

SCR4. Rail Capacity Problems – **C4**. Rail Throughput Capacity.

C4. Criterion derives from SCRM rail capacity risks. This dimension assesses the factors that limit the volume and speed of material movement by rail.

C4.1. Track Configuration (Double-Track): Measures the percentage of the route that utilizes double-track railway, which increases traffic throughput.

C4.2. Axle Load Allowance: Assess the rail network's load-bearing capacity to ensure the heavy cars carrying tanks can be utilized.

C4.3. Clearance Restrictions: Measures physical restrictions (height/width in tunnels, under bridges, mountain passages) for oversized military cargo.

C4.4. Terminal Availability and Capacity: Measures the availability of terminals (intermodal) to reload military equipment; receive, stage, and dispatch trains.

C4.5. Rail Wagons and Locomotives Availability: Measures sufficiency and compatibility of available rolling stock to handle the volume and type of military assets.

SCR5. Road Capacity Problems – **C5**. Road Throughput Capacity.

C5. Criterion derives from SCRM road capacity risks. This dimension assesses the network's ability to sustain high-volume, rapid military movement on roads.

C5.1. Highway Lane Density (Four-Lane): Measures the proportion of the logistical corridor utilizing multi-lane highway versus lower-capacity two-lane roads.

C5.2. Weight and Dimension Limits: Measures the most restrictive structural limitations, such as bridges (weight/axle load), tunnels (height/width clearance).

C5.3. Choke Point Frequency: Measures the number of bridges, tunnels, narrow passages along the route. These points slow down traffic and are vulnerable.

C5.4. Mountain Pass Frequency/Severity: Measures the number of complex mountain passes (steep grades, sharp turns, speed limits) and difficult terrain, which reduce convoy speed.

C5.5. Urban/Congestion Bypass Availability: Assesses the availability of bypass routes around urban areas, avoiding civilian traffic friction.

C5.6. Border Crossing: Measures the existence of international boundary passages and customs chokepoints along the route.

C5.7. Heavy Equipment Transporters (HETs) Availability: Measures sufficiency and compatibility of available HETs required to move tracked and oversized military vehicles.

SCR6. Airport Capacity Limitations – **C6**. Airport Capacity.

C6. Criterion derives from SCRM risk airport capacity risks. This dimension assesses the APOD's infrastructure to support movement of materiel and personnel.

C6.1. Runway Metrics: Measures the dimensions and strength of the runway to handle arrival/departure of heavy aircraft (C-17s).

C6.2. Forward Movement Integration: Measures the APOD's connection to road and rail networks, assessing the chokepoint risk for onward movement.

SCR7. Infrastructure Problems – **C7**. Network Resilience and Redundancy.

C7. Criterion derives from SCRM infrastructure risks (dysfunctional critical infrastructure, insufficient infrastructure support, redundancy risks, deficient national infrastructure). This criterion assesses the flexibility and robustness of the sustainment network.

C7.1. Route Redundancy and Bypass Availability: Measures the density of alternative routes and bypass options around potential Single Points of Failure, bypass options due to civilian disorder, evacuation.

C7.2. Network Connectivity and Meshedness: Measures the number of alternate paths between key nodes, indicating how flow can be dynamically rerouted following disruption.

C7.3. Interoperability and Standardization: Assesses the complexity and time required for network transitions due to differing (international) standard issues, such as railway width.

C7.4. Sufficient Host Nation Support Access: Measures the access to Reception, Staging, and Onward-Movement supporting capabilities and infrastructure.

C7.5. Emergency and Interim Support Facilities: Measures the availability and proximity of interim support facilities along the route (hospitals, rescue services, maintenance garages).

SCR8. Environmental Risks – **C8**. Geographical and Environmental Exposure.

C8. Criterion derives from SCRM constrained geography and environmental risks (natural events, accidents, disasters). It assesses vulnerability to threats from natural forces and geographical constraints.

C8.1. Severe Weather Susceptibility: Assesses the probability of disruptive weather (heavy snow, ice, fog, storms) that cause operational delays.

C8.2. Natural Disaster Exposure: Assesses the probability of high-impact natural events (floods, avalanches, mudslides, earthquakes, fire, hurricanes) that cause traffic disruption.

C8.3. Geographical Constraint Density (Terrain): Assesses the extent the route is constrained by narrow geography, rough terrain, mountains, water bodies, swamps, jungles, deserts.

C8.4. Canalization and Redundancy Limitation: Assesses how severe terrain canalizes movement, forcing traffic into limited paths and restricting bypass options.

SCR9. Complex Supply Chain – **C9**. Sustainment Line Performance and Efficiency.

C9. Criterion derives from SCRM complex supply chain risks (lead time, extended distances, increased pricing). This criterion assesses the complexity in the sustainment line and measures the performance outcomes of the mobility corridor.

C9.1. Travel Time: Measures the overall end-to-end travel time required for materiel and personnel to transit the route.

C9.2. Travel Distance: Measures the overall travel distance.

C9.3. Cost: measures the overall cost of utilizing the route, including transport expenditure, warehousing, customs, and managing complexity.

C9.4. Supply Line Complexity: Measures complexity, including the number of nodes, partners, mode switches, and administrative burden required for movement.