Greening corridors

Overcoming Barriers to Empty Container Repositioning

A Case Study of Maersk's Hinterland Operations in Rotterdam and Antwerp

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Samenvatting

Het herpositioneren van lege containers (Empty Container Repositioning, ECR) blijft een kostbare activiteit in de wereldwijde logistiek, omdat lege containers van gebieden met een overschot naar gebieden met een tekort moeten worden verplaatst zonder dat dit inkomsten oplevert. Hoewel ECR op mondiaal niveau goed is onderzocht, is er minder bekend over herpositionering op lokaal en regionaal niveau. Deze studie onderzoekt de belemmeringen voor directe herpositionering in het achterland binnen de netwerken van Maersk.

Met behulp van interne data, interviews, operationele analyses en financiële evaluaties laat het onderzoek zien dat slechts 12% van de ECR-bewegingen momenteel via directe routes van overschot- naar tekortlocaties verloopt. Dit wijst op een sterke afhankelijkheid van herpositionering via hubs.

Vanuit het perspectief van depotoperaties omvatten de belangrijkste belemmeringen voor directe herpositionering beperkte samenwerking tussen partijen, inconsistente voorraadniveaus, kwaliteitsproblemen van containers en seizoensgebonden variaties in stromen. Op corridor-niveau spelen factoren zoals locaties buiten de route, rigide transportschema's, gebrek aan geschikte diensten en fysieke beperkingen (zoals de grootte van binnenvaartschepen) een rol. De financiële analyse toont aan dat directe herpositionering kosten kan verlagen door extra overslag te vermijden. Operationele bevindingen benadrukken dat afstemming tussen stakeholders en planningspraktijken een grote invloed hebben op de efficiëntie.

De studie concludeert dat ECR niet alleen als een optimalisatieprobleem moet worden gezien, maar vooral als een coördinatievraagstuk. Verbeterde samenwerking tussen betrokken partijen en meer flexibiliteit in de planning zijn essentieel om directe, kostenefficiënte en effectieve herpositionering van lege containers in het achterland mogelijk te maken.

Abstract

Empty Container Repositioning (ECR) remains a costly activity in global logistics, as empty containers must be moved from surplus to deficit areas without generating revenue. While global ECR is well studied, local and regional repositioning are less understood. This study explores barriers to direct inland repositioning within Maersk's hinterland networks. Using internal data, interviews, operational assessments, and financial analysis, the research reveals that only 12% of ECR movements currently follow direct routes from surplus to deficit locations, indicating overdependence on hub-based repositioning.

From the point of view of depot operations, key barriers preventing direct repositioning include limited collaboration between vendors, inconsistent stock levels, container quality issues, and seasonal flow variations. At the corridor level, barriers include off-route locations, rigid transport schedules, lack of suitable services, and physical limitations like barge sizes. Financial analysis shows direct repositioning can cut costs by avoiding extra handling. Operational findings highlight that stakeholder coordination and planning practices significantly affect efficiency.

This study concludes that ECR should be viewed as a coordination challenge rather than just an optimization problem. Improving stakeholder collaboration and planning flexibility is essential for enabling more cost-effective and efficient direct inland repositioning of empty containers.

Introduction

Empty container repositioning is one of the most persistent challenges in maritime logistics. Shipping companies often adopt reactive strategies, prioritizing rapid container reuse to meet demand and optimize equipment use. However, reuse is not always possible, as import and export flows often require different container types, or the containers must meet specific quality standards suitable for their intended use (Olivo e.a., 2013). Strategic repositioning is therefore essential to reduce costs and maintain efficiency (Abdelshafie e.a., 2022). Managing empty containers demands similar resources as laden containers Rafael e.a. (2012), yet over half of a container's lifecycle is spent in non-revenue-generating phases like storage and empty repositioning (Brito & Konings, 2007). When poorly managed, these costs rank just below fuel as a carrier's largest expense (Abdelshafie e.a., 2022). Effective repositioning involves complex decisions around volumes, routing, timing, and equipment priorities (Abdelshafie e.a., 2022). Empty containers can be repositioned from surplus areas to deficient areas either directly or indirectly, via intermediate hubs. While hub-based repositioning dominates, direct inland repositioning, where two handlings two handlings at the hub are avoided, remains underutilized. This raises the question of what prevents shipping lines from using these direct connections more often between inland depots. Although different levels of repositioning exist, this research focuses on regional and local repositioning, which remain underrepresented in the literature (Rodrigue, 2013). Furthermore, prior studies have largely emphasized truck-based repositioning. In contrast, this paper investigates barge-based inland repositioning in the Rotterdam and Antwerp hinterland, where waterway infrastructure offers a sustainable and efficient alternative to road transport (Rijkswaterstaat, 2021).

Numerous models for inland repositioning have been proposed, many of which are stochastic, dynamic, and multi-commodity in nature (Braekers e.a., 2011), yet their practical implementation remains limited and complicated. High system complexity and integration demand inder adoption (Genc¸er & Demir, 2019; Vinh e.a., 2023), and therefore most repositioning systems still rely on simple heuristics and manual planning (Lee & Song, 2017). Although direct inland repositioning offers operational and cost advantages, its adoption is shaped not only by physical and financial factors but also by the complexity of stakeholder interaction. Inland repositioning typically involves a range of actors beyond the shipping line, including depot operators, inland carriers, terminal planners, and policymakers (Abdelshafie e.a., 2022; Mittal e.a., 2013; Song & Dong, 2015). These stakeholders often have differing objectives, operational constraints, and commercial agreements, which complicate coordination and decision-making (Gusah e.a., 2019; Jeevan e.a., 2018). Especially at the regional level, repositioning strategies are shaped by decentralized decision-making structures, where no single actor has full control over inland flows (Yu e.a., 2018). Prior studies have shown that such misalignment between ocean carriers and hinterland actors can lead to inefficiencies, underuse of direct connections, and reliance on hub-based systems (Boile e.a., 2008; Monios & Wang, 2014). To address the limitations of previous research, namely the emphasis on global optimization models and the underrepresentation of inland repositioning in practice, this paper investigates the barriers that hinder direct empty container repositioning between surplus and deficit depots in inland networks. Focusing on the Rotterdam and Antwerp hinterland and using internal Maersk data, the study applies a multi-method approach that combines network analysis, stakeholder interviews, and financial assessment. The aim is to understand how operational, organizational, and stakeholder-related factors interact to shape repositioning outcomes at the regional and local levels. In doing so, this research contributes to the literature by framing empty container repositioning not merely as a technical or logistical challenge, but as an inter-organizational coordination problem embedded in complex planning and incentive structures.

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The remainder of this paper is structured as follows: Section 2 presents the literature review on repositioning. Section 3 outlines the methodology, detailing the approaches used in this study. Section 4 presents an analysis of the results, followed by a discussion in Section 5. Finally, Section 6 concludes the paper.

Literature review on repositioning

Empty container repositioning (ECR) has been widely studied in the context of global shipping networks, with a strong emphasis on strategic optimization models. However, inland repositioning remains underexplored, especially in barge-based systems. This literature review addresses that gap by examining existing research on inland ECR, planning levels, stakeholder dynamics, and relevant insights from reverse logistics.

Inland empty containers repositioning

The repositioning of empty containers at regional scale – especially by barge transport - has been relatively underexplored (Braekers e.a., 2011; Monios & Wang, 2014; Lee & Song, 2017). Using barges for inland repositioning might result in cost and sustainability benefits, especially in regions with well-developed inland waterway networks, such as the Netherlands (Rijkswaterstaat, 2021). At the regional level, inland depots form the operational backbone of empty container repositioning. Studies consistently highlight their dual role as storage facilities and transshipment points for container repositioning (Abdelshafie e.a., 2023; Sianturi e.a., 2023). Several authors argue that direct repositioning between inland depots, rather than using maritime terminals, can reduce handling, costs, and environmental impact (Ghorpade & Rangaraj, 2019; Maersk, 2024; Song & Dong, 2015). According to Saeidi e.a. (2013) and Song & Carter (2009) the repositioning system is not only challenged by trade imbalances, but also by demand uncertainty, diverse container types, seasonal variation, carriers' operational and strategic practices, and infrastructure constraints.

Decision levels of empty container repositioning

Many studies categorize empty container repositioning (ECR) into three decision levels: strategic, tactical, and operational. The literature has largely focused on strategic and tactical planning, often emphasizing global scale optimization models (Braekers e.a., 2011; Song & Dong, 2012). However, regional and local-level management, the operational level, remains underexplored. Lee and Song (2017) highlight this gap, noting that most research overlooks day-to-day decisions in inland networks. Although Boile e.a. (2008) address regional repositioning, their work still focusses on strategic modeling. Similarly, Monios and Wang (2014) emphasize that most research concentrates on global-level optimization. Their study seeks to address this gap by examining the role of local and regional stakeholders in shaping empty container repositioning. However, their peripheral case limits applicability to major logistics hubs.

Stakeholders in empty container repositioning

The role of stakeholders is a recurring theme in the literature on empty container repositioning (ECR). While shipping lines are typically the central decision-makers, repositioning activities are influenced by a wider set of actors, including depot operators, inland carriers, policymakers, and planners (Gusah e.a., 2019; Jeevan e.a., 2018; Song & Dong, 2015). Several studies note that most ECR literature focuses on intra-organizational solutions from a single company's perspective, often overlooking the operational challenges and conflicting objectives faced by actors such as inland terminals and depot operators (Abdelshafie e.a., 2022; Song & Dong, 2015). At regional level, the complexity of ECR is amplified by the fragmented nature of decision-making. Local systems often involve multiple interdependent actors with diverging goals, making coordination difficult. In Melbourne, for instance, container flows are shaped by intricate relationships between regional stakeholders, highlighting the influence of contracts, power dynamics, and role fragmentation (Gusah e.a., 2019). Similarly, Mittal e.a. (2013) demonstrate through modeling how service agreements between depots and carriers strongly shape operational decisions, underlining the importance of stakeholder alignment. Monios and Wang (2014) emphasize the influence of local and regional actors, including public authorities and industry associations, on repositioning decisions, especially in peripheral regions that support regional exporters. However, findings based on peripheral areas may not fully generalize to high-traffic logistics hubs. Other studies also show that system coordination is not guaranteed in decentralized networks. Yu e.a. (2018) observe that when hinterland repositioning is managed by separate operators, misalignments between inland actors and ocean carriers often lead to inefficiencies. Boile e.a. (2008) complement this view by showing that even regional repositioning decisions are shaped by external forces, such as global trade flows, container costs, leasing practices, and the strategic priorities of global carriers. These structural pressures can constrain the agency of local planners and increase the need for policy alignment across governance levels. However, the system is not only challenged by trade imbalances, but also by demand uncertainty, diverse container types, seasonal variation, carriers' operational and strategic practices, and infrastructure constraints (Saeidi e.a., 2013; Song & Carter, 2009).

Knowledge gap in repositioning empty containers

On basis of the literature research, a knowledge gap is identified between theoretical models and practical implementation of improving the efficiency of repositioning empty containers - especially using barges - in the hinterland of large container ports. Empty container repositioning is influenced by trade imbalances, variable demand, infrastructure constraints, and intricate stakeholder relationships. While existing studies primarily focus on global optimization, limited attention has been given to operational-level challenges and decision-making at regional or company scales. There is an insufficient understanding of direct repositioning between surplus and deficit depots within hinterland networks. Although direct inland repositioning can offer both operational and cost benefits, its implementation is shaped by more than just physical or economic considerations, not always clearly visible in practice, and merely constrained by the complexity of stakeholder coordination. This research contributes to the field by framing empty container repositioning not solely as a logistical or technical issue, but as a problem of organizational coordination embedded in complex planning processes. This perspective highlights a critical knowledge gap: the lack of insight into the barriers hindering the adoption of direct inland repositioning.

Research methodology

This research is divided into two parts. The initial part focuses on how the network looks and which actors play a role in Empty Container Repositioning (ECR), while the next part uses available data to identify the factors that influence ECR decision-making and to assess the cost implications of direct inland repositioning compared to hub-based flows.

System and network analysis

Focusing on the hinterland regions of Rotterdam and Antwerp, the study examines the configuration of Maersk's current ECR network and the roles of various actors involved in repositioning decisions. A network analysis was conducted using internal Maersk data collected between November 2024 and March 2025. This analysis identified surplus and deficit depot locations and mapped routing patterns. To contextualize the network findings, a complementary system analysis was undertaken to explore decision-making processes within the ECR system. This involved a series of semi-structured interviews aimed at capturing stakeholder roles, interactions, and behavioral dynamics.

To gain operational insights into the constraints and coordination practices underlying empty container repositioning (ECR), interviews were conducted with both Maersk practitioners and external logistics vendors. These interviews provided grounded, practice-based perspectives from professionals directly responsible for managing container flows, rather than abstract expert commentary. The resulting stakeholder analysis served as the foundation for a broader system analysis, facilitating the identification of key actors, their responsibilities, and interdependence within the ECR process (Gulaugsson e.a., 2020). Several analytical tools were employed to deepen this analysis:

- A power-interest matrix was created to categorize stakeholders based on their influence over and involvement in ECR decision-making.
- A relationship map illustrated contractual and informational linkages, helping to identify coordination bottlenecks and critical dependencies.
- High-level process maps were developed for both internal Maersk planning workflows and those of external vendors, tracing decision points, actor roles, and emerging conflicts across different types of repositioning flows.
- A behavioral typology was constructed to classify recurring stakeholder behaviors relevant to inland repositioning decisions.

Combined, these methods provided a comprehensive understanding of the ECR network's physical structure as well as the organizational and behavioral dynamics that shape its real-world functioning.

Practitioner insights and financial data analysis

The second phase of the research investigates the barriers to implementing direct inland repositioning and assesses its financial viability relative to conventional hub-based flows. This part of the study analyzes the factors influencing decision-making around direct repositioning and examines the cost implications of adopting such alternatives. A heuristic matching approach was employed to identify surplus–deficit depot pairs based on volume and distance criteria, focusing exclusively on depot pairs without existing direct connections. These candidate corridors were then filtered based on routing feasibility and reviewed by Maersk planners to identify depot-level constraints. Corridors deemed operationally viable were subsequently validated by transport vendors, whose feedback determined the serviceability of each connection and the associated transport cost. Where proposed corridors were rejected, the underlying reasons were documented as corridor-level barriers. This validation process resulted in the identification of two categories of operational barriers—depot-level and corridor-level—which form the analytical basis for understanding the constraints to direct inland repositioning. For corridors confirmed as feasible, a financial evaluation was conducted using vendor rate data to assess cost-based competitiveness of direct flows compared to hub-based repositioning. The following formulas were applied to calculate the Direct route cost (from Terminal A to Terminal B):

$$C_{Direct} = C^{A}_{Handling} + C^{A\to B}_{Slot} + C^{B}_{Handling}$$

Hub-based route cost (from Terminal A to the Hub to Terminal B):

$$C_{Hub} = C^{A}_{Handling} + C^{A\to Hub}_{Slot} + 2C^{Hub}_{Handling} + C^{Hub\to B}_{Slot} + C^{B}_{Handling}$$

In cases where vendor rates were unavailable, a break-even analysis was performed to estimate the cost threshold at which direct inland repositioning would become financially viable. This component of the research integrates operational feasibility with financial assessment, providing practical insights into the underutilization of potentially efficient direct flows and identifying the conditions under which such flows could become economically and logistically feasible in the future.

Analysis of the results

This section details the empirical findings from the analysis of Maersk's inland Empty Container Repositioning (ECR) network within the hinterlands of Rotterdam and Antwerp. The results encompass the structural characteristics of the network, the roles and behaviours of key stakeholders, the determinants influencing direct inland operational repositioning strategies, and a financial evaluation comparing direct flows with those routed through hub-based systems.

Network analysis

This section examines the structure of Maersk's inland Empty Container Repositioning (ECR) network in the hinterland of Rotterdam and Antwerp. The dataset covers 84 locations: 65 inland depots and 19 hub-area sites in Rotterdam and Antwerp. Each depot is classified as surplus or deficit based on the two most common container types, 20DRY and 40HIGH. A 20-foot dry container (20DRY) is built for transporting dry cargo, with dimensions of 5.90 × 2.35 × 2.39 m and a door opening of 2.34 × 2.28 m. It has a tare weight of 2,300 kg, a payload capacity of 28,200 kg, and an internal volume of 33 m³. Typically, it can hold up to 11 EUR pallets. A 40-foot High Cube (40HIGH) container is a taller version of the standard 40-foot container, offering extra internal height for greater volume. It measures about 12.19 m long, 2.44 m wide, and 2.90 m high, with an internal capacity of 76 m³. Its tare weight is 3,900 kg, payload up to 28,600 kg, and it can fit around 27 EUR pallets.

The total imbalance in the network is shown in Table 1.

Table 1 Imbalances of trade per container type (Nov 2024-Mar 2025)

Container type	Total balance of trade value (units)
20DRY deficit	-7673
20DRY surplus	2932
40HIGH deficit	-9788
40HIGH surplus	15155

The analysis reveals distinct geographic imbalance patterns. For 40HIGH containers, surpluses are concentrated in regions such as the Lower Rhine and Limburg, while deficits are found in the Middle Rhine and along the Maas River in North Brabant. In contrast, 20DRY imbalances are more scattered and less pronounced, although the northern Netherlands consistently shows a deficit. Cumulative imbalance plots show moderate concentration: 23% to 39.5% of depots account for 80% of the total imbalance, depending on the container type and direction.

The flow analysis reveals a dominant reliance on hub-based repositioning: 88% of container movements occur between inland depots and hubs, while only 12% take place directly between inland depots. The hub network exhibits a star topology centered on Rotterdam and Antwerp (see Figure 1A), whereas the inland-inland network follows a fragmented, point-to-point configuration (see Figure 1B). Cross-border repositioning between the Netherlands, Belgium, and Germany is limited, reflecting Maersk's regionally segmented planning structure.

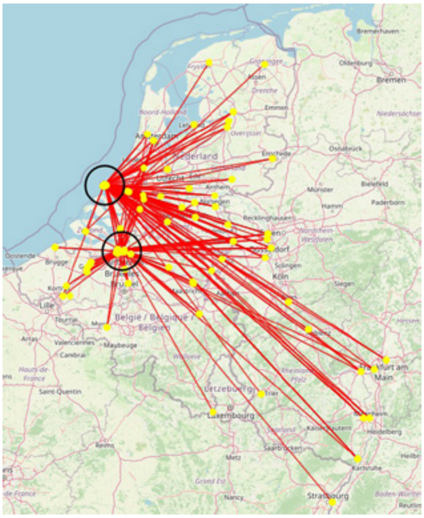


Figure 1A The connections between the hub areas and the inland depots in the hinterland.

Figure 1B Total handling and slot costs of hub-based repositioni Figure 1B. The direct connections between inland depots in the hinterland. ng per Container.

Overall, the findings highlight that the current ECR network is heavily reliant on hubs, structured around national regions, and shaped by imbalances that vary by container type, as well as influenced by organizational factors such as the country-oriented segmentation planning structure. This understanding informs the subsequent phases of this research, which investigate the stakeholder network and the feasibility and cost-effectiveness of direct inland repositioning as an alternative to hub-based flows.

Stakeholder analysis

This section shows how the inland Empty Container Repositioning (ECR) system around Rotterdam and Antwerp operates, with a focus on the actors involved, their roles, and how their interactions affect repositioning efficiency.

The ECR network comprises diverse stakeholders such as shipping lines, terminals, depots, vendors, port authorities, and importers/exporters. Each has a distinct role and strategic focus. Using a power-interest (PI) matrix (see Figure 2), these stakeholders are classified based on their influence and engagement in repositioning. Maersk holds the highest power and interest, while vendors and terminals possess medium power but are essential operational partners. Port authorities and shippers have lower influence but remain relevant for system responsiveness.

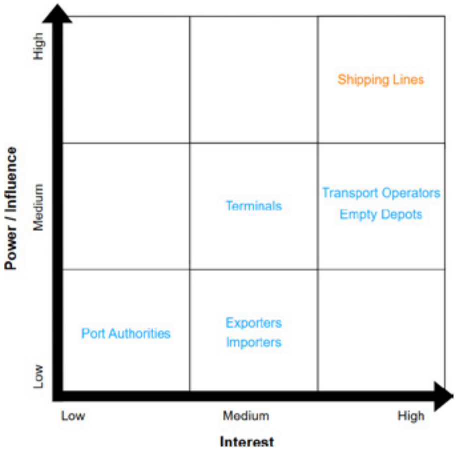


Figure 2 Power-interest matrix

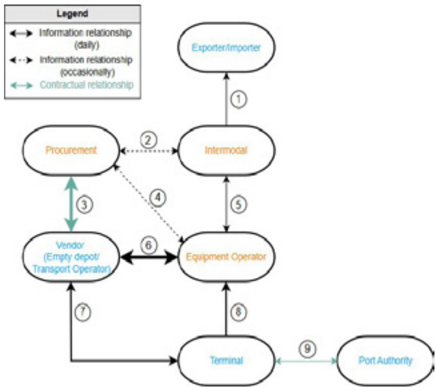


Figure 3 Relationships between stakeholders

The stakeholder relationships are mapped to illustrate the flow of information and contractual ties within the system (Figure 3). Coordination is particularly dense between Maersk's internal teams (Procurement, Inter- modal, Equipment Operator) and vendors, who often serve dual roles as both depot managers and transport providers. Relationships vary in intensity and frequency,

Daily repositioning decisions are primarily managed by the equipment operator and vendors. Direct inland repositioning between surplus and deficit depots faces hereby several barriers, including incompatible IT systems, limited transparency, and a lack of vendor agreements. Vendors prioritize their own schedules and rarely offer favourable time slots to third parties, while inland routes lack fixed service schedules and often result in empty backhauls. These factors make hub-based repositioning a more practical and preferred option despite its own limitations.

Barriers affecting ECR decision making

The network analysis identified 69 feasible inland corridor matches between surplus and deficit depots from an initial pool of 219 depot pairs. Filtering steps, based on routing feasibility, existing corridor use, and inland waterway accessibility, narrowed down the list, with the final matches involving 23 surplus and 12 deficit depots. The results are segmented by container type, revealing that repositioning is considerably more viable for 40HIGH containers than for 20DRY containers.

Depot-level analysis revealed significant limitations to repositioning at both surplus and deficit depots. Key barriers included seasonal stock patterns, intra-vendor flows that already absorb available capacity, and strict container quality requirements (e.g., food-grade standards). Especially in the 20DRY category, many depots either lacked sufficient surplus volumes or were unable to serve demanding destinations. Only 12 of the 40HIGH surplus depots and 4 of the 40HIGH deficit depots remained eligible for further evaluation, with the rest excluded due to operational, quality, or market-driven constraints.

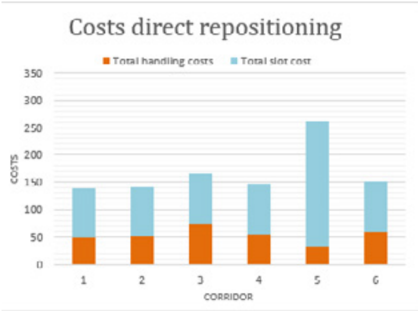
Out of the 25 depot pairs evaluated, only 6 were found to be operationally viable by the vendors, with different rates provided for each. In contrast, 19 corridor matches were dismissed due to barriers such as depot inaccessibility, off-route locations from hub paths, or fixed schedules incompatible with the required service. Some potential connections also failed due to the inability of surplus depots to provide sufficiently clean or certified containers, emphasizing the logistical and quality barriers to wider inland repositioning.

The effort required to overcome these barriers was ranked across multiple dimensions. Low-effort barriers, such as those related to temporary stock level changes, may be resolved through better planning and forecasting. Medium-effort barriers typically involve organizational coordination, such as aligning vendor schedules or establishing new vendor agreements. High-effort barriers, such as container quality requirements, infrastructural constraints, and lack of third-party access or slot availability, are more structural and less amenable to short-term solutions.

Ultimately, all the barriers found were also categorized: behavioural limitations (e.g., intra-group preferences, local optimization), structural barriers (e.g., IT misalignment, physical access restrictions), logistical constraints (e.g., routing and volume constraints), market conditions (e.g., seasonal variations, fluctuating stock levels), and quality constraints (e.g., food-grade or damaged containers).

Barriers affecting ECR decision making

The financial feasibility analysis focused on the six inland corridors where the vendors confirmed operational viability and provided rates. Each corridor was evaluated by comparing the total cost of direct repositioning with that of hub-based repositioning, incorporating both slot rates and handling charges (see Figures 4A/4B).



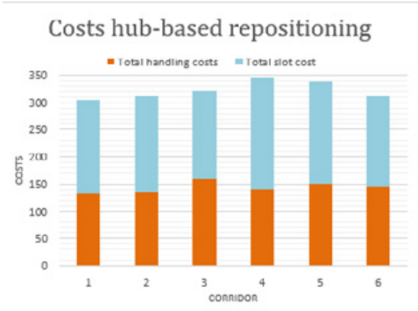


Figure 4A Total handling and slot costs of direct repositioning per Container. Power-interest matrix

Figure 4B Total handling and slot costs of hub-based repositioning per Container.

As expected, direct repositioning consistently demonstrated lower handling costs, primarily because it avoids the two additional and more expensive handlings at the hub terminal. Even in cases where the direct slot rate exceeded the combined slot rates of the hub-based route, the total costs remained lower due to reduced handling costs. For example, in Corridor 5, the slot rates cost for direct repositioning were higher, yet the overall costs were still favourable when accounting for handling savings. A cost breakdown across all six corridors confirmed annual savings of over €1.1 million, with individual savings per container ranging from €75 to €197 (Table 2). This corresponds to a 3.5% to 9.1% cost reduction relative to average container transport costs, as reported in Q2 2024 benchmarks. These findings validate that, when feasible, direct repositioning can be a financially attractive alternative to hub-based repositioning, providing meaningful savings even across a limited number of corridors.

Table 2 Estimated annual savings from direct inland repositioning (vs. hub-based)

Corridor	Price difference (€)	Volume (4 months)	Annual volume	Annual savings (€)
1	165	369	1,476	243,540
2	170	369	1,476	250,920
3	155	369	1,476	228,780
4	197	234	936	184,392
5	75	233	932	69,900
6	162	199	796	128,952

A break-even analysis was also conducted to estimate the maximum slot costs when direct inland repositioning remains financially viable compared to hub-based repositioning. This analysis combines the key cost components of hub-based repositioning, specifically, the slot cost from the surplus depot to the hub and the slot cost from the hub to the deficit depot , and two handling charges incurred at the hub terminal (2). These costs are compared with the slot cost for direct repositioning between the surplus and deficit depot . By equating the total cost functions of both approaches, the analysis yields the following break-even condition (3):

$$C_{Slot}^{A\rightarrow B} \leq C_{Slot}^{A\rightarrow Hub} + 2C_{Handling}^{Hub} + C_{Slot}^{Hub\rightarrow B} \qquad (3)$$

This inequality defines the transport cost margin within which direct repositioning becomes cost neutral. It serves as a practical benchmark for planners to assess the financial viability of new inland corridors under current vendor rate.

Discussion

This study evaluated the feasibility of direct inland repositioning of empty containers within Maersk's hinterland network, identifying both substantial cost-saving potential and operational constraints to broader adoption. The findings indicate that even a limited set of viable corridors can yield significant financial benefits, primarily by avoiding costly hub-based handling. Nonetheless, several limitations must be considered when interpreting these results.

The analysis was based on a static four-month dataset, which may not capture long-term patterns or seasonal variability. While the time frame was adequate for identifying imbalances and testing corridor feasibility, container stocks and flows are inherently dynamic, warranting periodic reassessment with updated data. Similarly, the use of Euclidean distances as a routing proxy simplifies operational reality, as actual sailing routes are often longer; although this approximation was sufficient for initial screening, future studies should incorporate more accurate routing information.

The financial analysis mainly focused on the cost savings by reducing transportation and handling cost. It showed that this heuristic approach can pinpoint potential cost saving connections between depots of empty shortage/surplus. It is a first step. Additionally, the cost effects for the the asset management dimension of the problem, where shipping lines have set up a system (with regional segments, and equipment managers) that is geared towards the turning around of empty containers for reloading. Not only are the cost savings important to consider but also the time to have the container available for the next load. This could be a next step extending the financial assessment by calculating the added value of having container earlier available to the market.

Conclusion

This study has answered the research question: What are the key barriers to establishing direct inland connections for Empty Container Repositioning (ECR) between surplus and deficit locations for shipping lines? The findings show that ECR is not simply about matching volumes across locations but is embedded in a complex socio-technical system shaped by decentralized planning, fragmented responsibilities, and misaligned stakeholder incentives. From Maersk's perspective, even when direct inland connections appear feasible in terms of distance and volume, implementation is often hindered by constraints outside the company's direct control.

Through a layered analysis, combining stakeholder mapping, operational screening, and financial evaluation, this study has identified key barriers at multiple levels of the system. Logistical constraints, such as fixed schedules, off-route depots, and existing flows where depots already use inland connections to absorb surpluses or meet deficits, consistently prevent viable repositioning routes. In addition, market-driven fluctuations in stock levels create shifting imbalances, while quality constraints require containers to meet specific standards before they can be reused. A structured classification of these barriers, paired with an effort-based assessment of their solvability, highlights where targeted interventions are most likely to succeed. Particularly, medium- effort, high-frequency barriers such as lack of service availability and internal flow rigidities stand out as realistic starting points for improving inland repositioning.

Strategically, improving inland ECR performance demands more than network reconfiguration, it requires collaborative action, organizational alignment, and better data visibility. Technical feasibility alone does not guarantee corridor usage; the effectiveness of repositioning depends equally on the willingness and capacity of stakeholders to act beyond routines and providing insight in operational factors. Investments in inland depot upgrade capacity, cross-vendor service coordination, and transparent container quality management can enable more resilient and cost-effective inland flows.

This study contributes to the literature on Empty Container Repositioning (ECR) by shifting the analytical focus from global optimization models to the operational realities of inland networks. It introduces a heuristic-based matching method grounded in practical planning constraints, emphasizing proximity and volume compatibility over exhaustive optimization. While consistent with earlier heuristic approaches (Ghorpade & Rangaraj, 2019), the method addresses a gap identified by Braekers e.a. (2011) concerning the absence of regionally grounded, actionable tools for inland repositioning.

Beyond its methodological contribution, the research integrates qualitative and quantitative perspectives to demonstrate how logistical, behavioral, market, structural, and quality-related factors act as barriers to the implementation of direct inland repositioning. Factors are reframed not just as drivers of repositioning but as barriers to execution (Saeidi e.a., 2013; Satir & Basarici, 2019; Song & Carter, 2009). In doing so, the study advances a practical framework that links strategic considerations with day-to-day decision-making, thereby introducing a socio-technical perspective into container logistics.

Looking forward, future research should expand the geographic scope to other ports and carriers, incorporate more dynamic and complete cost models, and investigate how container condition standards influence repositioning efficiency. With respect to cost the asset management perspective could be considered. Shipping lines prioritize the rapid turnaround of empty containers for the next load. Beyond cost savings, the time needed to make containers available again is crucial. Extending the financial assessment to estimate the value of earlier availability could provide additional insight. Agent-based modeling (ABM) is also a promising method to simulate system-wide impacts of barrier removal and evaluate which combinations of interventions produce the greatest benefit. Unlocking the full potential of inland repositioning requires the integration of planning realities, incentive structures, and inter-organizational coordination between shipping lines and vendors.

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