

Assessing risk dimensions in dry port projects: prioritization, interdependence and heterogeneity

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Abstract

Purpose – We identify and further aggregate the most commonly engaged risk factors in dry port projects into dimensions. Noting the importance of developing a multi-perspective view of risk, we further assess the priority, interdependency and heterogeneity of the identified risk dimensions.

Design/methodology/approach – We identified 44 risk factors from the literature, which were aggregated via exploratory factor analysis (EFA) into 8 major risk dimensions. We employ a fuzzy-based decision-making trial and evaluation laboratory (DEMATEL) relationship map to articulate various relationships among the risk dimensions.

Findings – “Cost” emerged as the most important risk influencing the success of the dry port project, followed by “location,” “accessibility,” “infrastructural” and “operational,” which were also ranked prominently.

Originality/value – This study offers significant insights into the management of risk in dry port projects. By aggregating key risk factors into distinct dimensions, we develop a structured framework for effective risk assessment and management. The insights gleaned from the study extend globally as it serves as a concrete knowledge base to understand potential barriers to successful dry port projects.

Keywords Dry port projects, Risk identification, Priority, Interdependencies, Heterogeneity, Multistakeholder perspective

Paper type Research paper

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1. Introduction

Dry ports are considered an essential node within the container shipping system, replicating several services performed at a seaport, such as customs clearance, container storage and depot, cargo consolidation, de-consolidation and tracking services, among others (Roso, 2007; Kwateng *et al.*, 2017; Rodrigues *et al.*, 2021a). Dry ports are major infrastructure facilities. However, their development is often marred by numerous reported instances of dry port failure (see Alam, 2016; Jeevan, 2016; Catve, 2020; Rodrigues *et al.*, 2024). These failures can occur at various stages of their development and operations (Rodrigues *et al.*, 2024).

The development and operation of dry ports have been extensively discussed in previous literature (Roso and Lumsden, 2010; Khaslavskaya and Roso, 2020; Miraj *et al.*, 2021). A major area of research interest in dry ports relates to risks (Nguyen *et al.*, 2022). Here, we draw on Marshall and Ojiako (2013) to define “risks” as “... possible future states of the world, which will negatively impact exposed subject” (p. 1227). Conversely, we draw on Rodrigues *et al.* (2024) to define “risk factors” as “... the broad associability of risk with causes and outcomes that are capturable together via quantitative research” (p. 2). Risk management is an action that can be employed to mitigate the potential adverse consequences of risks (Marshall *et al.*, 2019). Risk management comprises several stages, including “identification,” “prioritization,” “analysis,” “evaluation,” “treatment” and “monitoring and control” (Bryde *et al.*, 2023). Our present study focuses on risk identification and prioritization set within the context of dry ports.

The dry port operation literature, specifically related to risk, is not fully developed. There are several reasons for this, including its complex nature. One area of associated complexity relates to stakeholder heterogeneity and multiplicity. Several stakeholder groups are involved in dry port project operations (Jeevan *et al.*, 2022). They include transporters, haulers, shippers, consignees and forwarders. They not only perform very diverse roles (e.g. trucking, loading/unloading, shipping, payment and consolidating) but also have very different interest. Dry port stakeholder heterogeneities inevitably will lead to varying perspectives on the relevance, priority and interdependence of risks (Marshall *et al.*, 2019). This variance among stakeholders groups and individuals within each group is based on differences in knowledge, information, positions, interests and values held by stakeholders (Machiels *et al.*, 2023). To ensure coherent and effective risk management, it is necessary to develop a concise understanding of relevant risks. Categorizing risks into broader dimensions can facilitate their effective management (Khan *et al.*, 2021). Considering the evidence that dry port projects are highly susceptible to failures (Rodrigues *et al.*, 2021a, 2024), we aim in this study to examine the priority, interdependency and heterogeneity of the most commonly engaged risk dimensions that may affect dry port projects and, hence, their operational success. To address this aim, we present three research questions:

- RQ1. How can risk factors be aggregated into dimensions in dry port projects?
- RQ2. What are the interdependencies of commonly engaged risk dimensions in dry port projects?
- RQ3. How do multistakeholder heterogeneity perspectives influence the prioritization of risk dimensions in dry port projects?

The rest of the paper is structured as follows. Following this introduction, Section 2 presents a brief overview of the literature on dry port project and risk management interdependency and heterogeneity. Section 3 describes our six-stage methodology. The results are presented in Section 4. We discuss the findings in Section 5 and conclude it in Section 6 with suggestions for future studies.

2. Literature review

Several prior studies have explored risk factors in dry ports. Some of these risks may be internal. For example, Dadvar *et al.* (2011) explored on regulations and customers’ outlook,

Lättilä *et al.* (2013) and Chang *et al.* (2019) focused on cost considerations and van Nguyen *et al.* (2020) focused on geographic location decisions. Other risks may be *external*. For example, Rodrigues *et al.* (2021a) highlight political risks, Ng *et al.* (2013) highlight the country regulatory landscape and Wang *et al.* (2022a) identify the dynamics of the seaport-hinterland system as external risks to dry port projects.

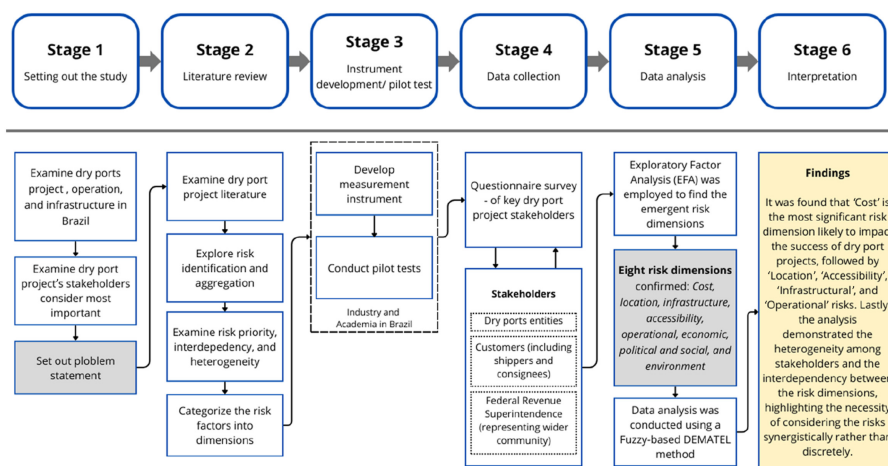
Prior studies specifically focused on risk management in dry port projects, which include Ciortescu and Păvălașcu's (2012) study that sought to explore the theoretical foundations of risk assessment and management in dry port operations. Their study interest was on how risk management strategies serve as the foundation for efforts directed at enhancing the economic performance of dry ports. Wang *et al.* (2022a) focused on concurrent exploration of diversity risks in dry ports from the perspective of asymmetric risk behaviors of key dry port stakeholders. Wang *et al.* (2022a) was further extended in Wang *et al.* (2022b) with the development of a two-period model that takes asymmetric and ambiguous stakeholder risk behaviors into consideration. Employing a fuzzy analytic hierarchy process to develop a continuous risk matrix model, Hsu *et al.* (2023) undertook a risk assessment of work safety in dry ports. While the study by Wide *et al.* (2023) does not explicitly focus on risk management, it is relevant in that it explores how operational disruptions (which can be construed as a form of risk) in dry ports can be managed with the support of information. A scenario-based simulation model was developed, with results showing that resource utilization can be increased through the exploitation of relevant support information. A recent study that has examined risk management in dry port projects and operations is Rodrigues *et al.* (2024). Focusing on the interface between facility completion and commencement of the operations phase of dry ports (i.e. handover to the operations phase), they examine and prioritize transitional risk at the handover stage of dry ports. Their study further highlights the potential implications of transitory “blind spots” that can arise at important moments of dry port handover.

3. Methodology

The six-stage methodology employed in this study is drawn from Chipulu *et al.* (2019) and Al-Mazrouie *et al.* (2021). We show the steps in Figure 1.

3.1 Stage 1: study context

We commenced the study by setting out our study context, which is set in Brazil. With a territory spanning approximately 8.5 million square kilometers, Brazil stands as the fifth



Source(s): The authors

Figure 1.
Diagrammatical
representation of the
research approach

largest country in the world in terms of land area. Brazil's coastline spans approximately 7,491 kilometers, ranking as the 16th longest globally (CIA, 2020). Brazil significantly contributes to global international trade and maritime cargo transportation (Rodrigues *et al.*, 2023a, b), standing as the world's 20th largest economy in terms of container handling (UNCTAD, 2022).

In Brazil, there are currently 56 dry ports in operation, mainly situated in the southeast (29) and south (17) regions of the country. These dry ports are classified according to Roso (2007) as “close” (28), “midrange” (19) and “long distance” (9), with average distances from seaports by road being approximately 30 km, 248 km and 831 km, respectively (Rodrigues *et al.*, 2021b). Furthermore, 31 dry ports are city-based, 20 are seaport-based and 5 are border-based. In terms of configuration, 10 of these dry ports are bimodal, 9 are connected by railway and one by barge, with the remaining 46 being unimodal. Dry ports in Brazil operate under concession or permission regimes overseen by fiscal auditors of the Federal Revenue, enabling customs clearance and additional services within the same facility (Ng *et al.*, 2013).

3.2 Stage 2: identification of risk factors

Adopting an approach similar to that of Chipulu *et al.* (2019) and replicated in Al-Mazrouie *et al.* (2021) and Doyle *et al.* (2020), we identified the initial risk factors from the literature. The literature search was undertaken in the Scopus and Web of Science databases. We focused on articles published in English, Spanish and Portuguese between 2000 and 2019. We considered an approximate 20-year period sufficient to produce a relevant, yet comprehensive range of risk factors that will still be relevant. Keyword searches were conducted using “dry ports” and the variants as follows: “intermodal freight centre,” “intermodal freight terminal,” “freight nodal terminal,” “inland port” and “container freight station.” The rationale for this selection is that they are all these variants known as associated with the dry port concept of the past (Rodrigue and Notteboom, 2022). We conducted additional searches for “dry port success,” “dry port implementation,” “dry port risk,” “dry port project,” “dry port operations” and “dry port readiness.”

The search generated 254 publications. A total of 86 duplicate articles were subsequently removed. Next, we conducted separate appraisals of the remaining articles to ensure agreement on their suitability. We adopted the selection criteria described in more detail in Chipulu *et al.* (2019). This involved each of the co-authors estimating the extent to which they viewed the publications as relevant according to the study criteria based on assigned relevance; “not relevant” papers were assigned a value of “0,” “perhaps relevant” papers were assigned a value of “1” and “definitely relevant” were assigned a value of “2.” Total values were summated, with papers with a value of either “0” or “1” being eliminated (90 publications were eliminated). This left us with 78 articles.

Next, a full and comprehensive collation (from a detailed review of each of the publications) of identified risk factors from the selected 78 articles was undertaken, and then they were organized into risk dimensions. These dimensions served as the foundation for this risk typology of a dry port project. In terms of organizing the risk factors from the publications into themes, the process followed was similar to that adopted during the database filtering. Each of the 78 publications was reviewed by the co-authors of this study, ensuring that all risk factors derived from each paper were identified and recorded.

We then examined the face validity of the identified risk factors highlighted in the 78 articles. Using responses of “0” for “not at all,” “1” for “somewhat matches” and “2” for “very closely matches,” the identified risk factors were grouped thematically. In sum, from the 44 risk factors identified, 8 dimensions were generated, namely “cost,” “location,” “infrastructure,” “accessibility,” “operational,” “economic,” “political and Social” and “environment.”

3.3 Stage 3: instrument development and pilot test

A survey comprising three sets of closed questions was then developed using Google Forms. Apart from respondent biographical information, respondents were presented with 52 questions against a 5-point Likert-type scale ranging from “0” (“*very low importance*”) to “5” (“*very high importance*”). Two sets of pilot exercises were conducted in March 2020. One with two senior managers with relevant experience in dry port operations. This was followed by a pilot exercise conducted with 13 doctoral and master’s candidates at the Universidade Federal de Pernambuco, Recife (Brazil), who were then contacted to test the reliability and validity characteristics of the research instrument.

3.4 Stage 4: data collection

Following the completion of the instrument development piloting, data were collected from three stakeholder groups involved in dry port operations in Brazil: (1) “*dry port entities*” (DPEs), (2) “*customers*,” which includes shippers and forwarders, and (3) the “Federal Revenue Superintendence” (FRS), a government entity regulating dry port projects and operations in Brazil. The data were collected between April 2020 and July 2020. For the DPEs, all 38 companies managing the 56 dry ports in Brazil were contacted. From this group, we obtained 34 valid responses. For the “*Customers*” group, noting that there are no dry port customer databases in Brazil, we contacted shippers and consignees from a database obtained from the CIB (2016) and Brazilian Suppliers (2020). This database contains the details of 8,556 companies. From this database, we obtained 42 responses. We subsequently contacted the 10 FRS superintendence offices and received responses from 7 office responses. Table 1 provides an overview of the sample.

3.5 Stage 5: data analysis

Data analysis was conducted in two steps. We first sought to aggregate the 44 risk factors into 8 risk dimensions using exploratory factor analysis (EFA). Specifically, we conducted eight separate EFAs using FACTOR 10.10.03 software. The model was iteratively adjusted until parameter fitting was appropriate to demonstrate validity and reliability. Each EFA evaluated unidimensionality and factor loading, categorizing the 44 factors into 8 risk dimensions. Fuzzy-based decision-making trial and evaluation laboratory (DEMATEL) was then employed to analyze the data, elucidating the priority, heterogeneity and interdependency of risk dimensions. The essence of this process is to capture the practical rationality and actions of the involved stakeholders in their preferred terms. This stage of the study involves constructing the resulting causal diagram risk dimensions ranking, considering the three major stakeholder perspectives that contribute to the input of practical rationalities. Based on the results from fuzzy-based DEMATEL, the risk dimensions in the dry port project were ranked, and their heterogeneity and interdependency were identified. The phases for applying the fuzzy-based DEMATEL method are outlined in the following section.

3.5.1 Fuzzy-based DEMATEL. We commenced on the assumption that the membership functions have a triangular shape (Mangla *et al.*, 2018). Triangular fuzzy numbers use a triplet (a, b and c) where a, b and c represent the smallest, most promising and largest possible values, making it easier to model and understand uncertainty in fuzzy logic applications (Khompatraporn and Somboonwiwat, 2017). Hence, we utilized triangular fuzzy numbers to handle fuzzy linguistic values in the influence scoring process of the DEMATEL method. The definition of triangular fuzzy numbers is outlined in Table 2.

Our use of fuzzy-based DEMATEL method is based on the five stages as set out in Khompatraporn and Somboonwiwat (2017). Phase 1 evaluates the relationships between risk dimensions using a fuzzy linguistic scale. Respondents were presented with a linguistic

Sample characteristic		Dry port entities	Customer	FRS	Total
Sample	Participants	31*	39	7	77
	Population	38	–	10	–
Actuation zone	Southeast	18	20**	3	41
	South	7	31**	–	38
	Northeast	6	12**	2	20
	Middle-west	–	10*	1	11
Gender	North	–	9*	1	10
	Male	28	34	6	68
	Female	3	5	1	9
Age	More than 50 years	12	7	2	21
	Between 40–49 years	7	17	4	28
	Between 30–39 years	11	10	1	22
	Between 20–29 years	1	5	–	6
Experience	More than 20 years	14	16	4	34
	Between 15–19 years	8	8	–	16
	Between 10–14 years	3	6	2	11
	Between 5–9 years	3	4	1	8
	Between 0–4 years	3	5	–	8
Position	Owner	–	8	–	8
	CEO/Director	8	6	–	14
	Superintendent	–	–	7	7
	Senior manager	17	10	–	27
Educational level	Specialist	6	15	–	21
	Postgraduate	20	22	3	45
	Graduate	9	17	4	30
	Other	2	–	–	2

Table 1.
Sample characteristics

Note(s): *31 participants from 26 dry port entities
**Customers act in many regions of the country
Source(s): The authors

Linguistic description	Influence score	Triangular fuzzy numbers
No influence	0	(0, 0, 0.25)
Low influence	1	(0, 0.25, 0.5)
Medium influence	2	(0.25, 0.5, 0.75)
High influence	3	(0.5, 0.75, 1)
Very high influence	4	(0.75, 1, 1)

Table 2.
Fuzzy linguistic scale

Source(s): The authors

judgments survey as asked to evaluate the degree to which risk dimension i is likely to affect dimension j . The resulting influence scores were then converted into fuzzy linguistic values using triangular fuzzy numbers, as depicted in Table 2.

We then (Phase 2) established the group direct-influence fuzzy matrix $\tilde{Z} = [\tilde{z}_{ij}]_{n \times n}$. Through linguistic judgments converted into fuzzy values, a fuzzy pair-wise comparison matrix $\tilde{Z}_k$ was constructed for each expert. Subsequently, individual matrices $\tilde{Z}_k = (k = 1, 2, \dots, l)$ were created. The group direct-influence fuzzy matrix $\tilde{Z} = [\tilde{z}_{ij}]_{n \times n}$ was then calculated by aggregating all the experts' judgments. In this matrix, $\tilde{z}_{ii}$ is represented as a triangular fuzzy number in the form (0, 0, 0) and $\tilde{z}_{ij}$ is determined as follows:

$$\tilde{z}_{ij} = \left(\tilde{z}_{ij1}, \tilde{z}_{ij2}, \tilde{z}_{ij3} \right) = \frac{1}{l} \sum_{k=1}^l \tilde{z}_{ij}^k = \left(\frac{1}{l} \sum_{k=1}^l \tilde{z}_{ij1}^k, \frac{1}{l} \sum_{k=1}^l \tilde{z}_{ij2}^k, \frac{1}{l} \sum_{k=1}^l \tilde{z}_{ij3}^k \right)$$

We then (Phase 3) generated the normalized direct-influence fuzzy matrix $\tilde{X}$ by:

$$\tilde{X} = \frac{\tilde{Z}}{r},$$

where

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{n1} & \tilde{x}_{n2} & \cdots & \tilde{x}_{nn} \end{bmatrix},$$

$$r = \max_{i,j} \left[\max_{1 \leq i \leq n} \left(\sum_{j=1}^n \tilde{z}_{ij3} \right), \max_{1 \leq j \leq n} \left(\sum_{i=1}^n \tilde{z}_{ij3} \right) \right]$$

Phase 4 obtains the total-influence fuzzy matrix $\tilde{T} = [\tilde{t}_{ij}]_{n \times n}$ by:

$$\tilde{T} = \lim_{h \rightarrow \infty} \left(\tilde{X}^1 + \tilde{X}^2 + \dots + \tilde{X}^h \right) = \tilde{X} \left(1 - \tilde{X} \right)^{-1}$$

when

$$\lim_{h \rightarrow \infty} \tilde{X}^h = 0$$

Here $\tilde{t}_{ij} = (\tilde{t}_{ij1}, \tilde{t}_{ij2}, \tilde{t}_{ij3})$ and

$$T_1 = \left[\tilde{t}_{ij1} \right]_{n \times n} = X_1(I - X_1)^{-1}$$

$$T_2 = \left[\tilde{t}_{ij2} \right]_{n \times n} = X_2(I - X_2)^{-1}$$

$$T_3 = \left[\tilde{t}_{ij3} \right]_{n \times n} = X_3(I - X_3)^{-1}$$

in which $X_1 = [x_{ij1}]_{n \times n}$, $X_2 = [x_{ij2}]_{n \times n}$, $X_3 = [x_{ij3}]_{n \times n}$ and I is an identity matrix. The elements of triangular fuzzy numbers in the matrix $\tilde{T}$ are divided into T_1 , T_2 and T_3 and $T_1 < T_2 < T_3$, when $x_{ij1} < x_{ij2} < x_{ij3}$ for any $i, j \in \{1, 2, \dots, n\}$.

Lastly, in we produced (Phase 5) an Influential Relation Map (IRM). After obtaining the total-influence matrix $\tilde{T}$, the $\tilde{R}_i + \tilde{C}_i$ and $\tilde{R}_i - \tilde{C}_i$ variables are calculated, where $\tilde{R}_i$ and $\tilde{C}_i$ are the sum of rows and the sum of columns, respectively, within the matrix $\tilde{T}$. Subsequently, the fuzzy numbers of $\tilde{R}_i + \tilde{C}_i$ and $\tilde{R}_i - \tilde{C}_i$ are converted into crisp values using the defuzzification method CFCS, as follows (Opricovic and Tzeng, 2003).

$$\gamma_i = L + \Delta \times \frac{(m_i - L) \times (\Delta + u_i - m_i)^2 \times (R - l_i) + (u_i - L)^2 \times (\Delta + m_i - l_i)^2}{(\Delta + m_i - l_i) \times (\Delta + u_i - m_i)^2 \times (R - l_i) + (u_i - L) \times (\Delta + m_i - l_i)^2 \times (\Delta + u_i - m_i)}$$

where y_i denotes the defuzzified value of the fuzzy number $\tilde{y}_i = (l_i, m_i, u_i)$, $L = \min l_i$, $R = \max u_i$ and $\Delta = R - L$.

To complete the fuzzy-based DEMATEL, the IRM is drawn by mapping the ordered pairs of $(\tilde{R}_i + \tilde{C}_i)^{\text{def}}$ as a horizontal axis vector named “Prominence” and $(\tilde{R}_i - \tilde{C}_i)^{\text{def}}$ as a vertical axis vector named “Relation.”

Once the total-influence fuzzy matrix $\tilde{T}$ was obtained, the results were interpreted from the sums of rows ($\tilde{R}$) and columns ($\tilde{C}$) within the total-influence matrix. More specifically, the fuzzy “prominence” degree ($\tilde{R} + \tilde{C}$) was utilized to express the strength of influences that are given and received for each dimension in the system. Similarly, the “relation” degree ($\tilde{R} - \tilde{C}$) was utilized to express the net effect that each risk dimension exerts upon the system. Then, the fuzzy numbers were converted into crisp values ($R + C$) and ($R - C$) by the defuzzification method detailed above. If ($R - C$) is positive, then this indicates that the risk dimension has a net influence on the other dimensions and can therefore be categorized into a “cause” group. Conversely, if ($R - C$) is negative, then this suggests that the risk dimension is being influenced by the other dimensions as a whole and should therefore be categorized into an “effect” group instead (Si *et al.*, 2018).

4. Results

4.1 Risk identification

Identification of the pertinent risk factors based on a literature survey resulted in 44 risk factors (see Table 3). For their validation, EFA was conducted across eight structures, each segregated by dimensions. Parallel analysis (PA) was utilized to determine the number of dimensions extracted, a method recommended over the eigenvalues-greater-than-1 rule (Timmerman and Lorenzo-Seva, 2011). Ensuring the suitability of the survey data, the Kaiser–Meyer–Olkin (KMO) measure for sampling adequacy and the Bartlett’s test of sphericity for assessing the suitability of using EFA for data reduction resulted in values higher than 0.5 and p -value < 0.05, respectively, indicating the adequacy of the sample size (Field, 2013).

The first risk dimension identified as representing a meaningful category for assessing project outcomes was “*cost*.” As a major risk in dry port projects, cost is important because of its role in economic decisions (i.e. evaluation) associated with dry ports. Costs also serve as a major driver for value creation, ensuring that dry port projects are not only completed on time but are fully aligned with strategic goals. The second risk dimension identified was “*location*.” Viewed geographically as an intermodal hub or platform, the success of dry port projects also faces risks in terms of their physical location. Wang *et al.* (2017), for example, opine that location is often the chief determinant of the competitive success of dry ports. In particular, a well-located dry port will offer a number of advantages including cargo volume optimization.

The third risk dimension identified was “*infrastructure*.” Infrastructure is arguably a key driver for cargo handling effectiveness and efficiency, especially considering the importance of congestion avoidance for dry port operation effectiveness (Chang *et al.*, 2019). The fourth risk dimension identified was “*accessibility*.” It focuses on how easily different inland transport infrastructures can be connected to the dry port (Nguyen and Notteboom, 2016). Accessibility can be measured by a combination of distance to the nearest intermodal exit, average daily traffic and level of service. The functioning and development of most dry ports around the world (Jeevan *et al.*, 2017). We also identified the “*operational*” as a risk dimension (fifth). These are risks associated with defective events, policies, processes and systems that

Code	Dimensions/ factors	Factor loadings	Dimensions (PA)	KMO	Bartlett's sphericity Chi- square	df	p- value	Explained variance	Cronbach's alpha
<i>D1</i>	<i>Cost</i>		1	0.730	209.6	10	0.000	65.39%	0.804
F1	Facility cost	0.510							
F2	Transportation cost	0.691							
F3	Storage cost	0.937							
F4	Additional services cost	0.884							
F5	Congestion cost	0.638							
<i>D2</i>	<i>Location</i>		1	0.790	100.4	6	0.000	77.40%	0.757
F6	Demand for dry port's services (excluded in run 2)	0.496							
F7	Distance between dry port and customers	0.745							
F8	Distance between dry port and seaport	0.613							
F9	Proximity with other logistic facilities	0.753							
F10	Size of hinterland population (excluded in run 1)	0.463							
F11	Cargo transportation time	0.749							
<i>D3</i>	<i>Infrastructure</i>		1	0.678	919.1	6	0.000	82.72%	0.827
F12	Dry ports' total area	0.834							
F13	Dry ports' yard capacity	1.014							
F14	Dry ports' warehouse capacity	0.771							
F15	Dry ports' expansion capacity	0.629							
F16	Multimodal infrastructure (excluded in run 2)	0.378							
F17	Equipment infrastructure (excluded in run 1)	0.378							

(continued)

Table 3.
EFA results

Code	Dimensions/ factors	Factor loadings	Dimensions (PA)	KMO	Bartlett's sphericity			Explained variance	Cronbach's alpha
					Chi- square	df	p- value		
<i>D4</i>	<i>Accessibility</i>		1	0.793	431.4	28	0.000	63.24%	0.860
F18	Accessibility to airports	0.777							
F19	Accessibility to seaports	0.875							
F20	Accessibility to railways	0.665							
F21	Accessibility to highways	0.700							
F22	Accessibility to other facilities	0.731							
F23	Accessibility to customers	0.606							
F24	Transportation capacity between dry port and seaport	0.847							
F25	Quality of network transportation infrastructure	0.763							
<i>D5</i>	<i>Operational</i>		1	0.810	221.6	15	0.000	74.33%	0.798
F26	Set of operational services offered	0.789							
F27	Container handling capacity (per day)	0.745							
F28	Information and technology system	0.596							
F29	Operational execution time	0.806							
F30	Cargo security and monitoring	0.742							
F31	Dry port's occupation (yard and warehouse)	0.689							
<i>D6</i>	<i>Economic</i>		1	0.781	126.6	6	0.000	78.63%	0.804
F32	Gross domestic product (GDP) rate	0.848							
F33	Dollar rate	0.646							
F34	Trade market (export and import)	0.770							
F35	Purchasing power of hinterland population	0.735							

Table 3. (continued)

Code	Dimensions/ factors	Factor loadings	Dimensions (PA)	KMO	Bartlett's sphericity Chi- square	df	p- value	Explained variance	Cronbach's alpha
D7	<i>Political and social</i>		1	0.799	159.6	10	0.000	70.56%	0.788
F36	Customs' rules	0.582							
F37	Job creation	0.750							
F38	Government financial incentive	0.757							
F39	Political and business environment	0.861							
F40	Bureaucracy for opening new companies and dry ports	0.653							
D8	<i>Environment</i>		1	0.799	243.7	6	0.000	86.01%	0.891
F41	Urban and environmental impact due to dry port facility	0.812							
F42	Noise reduction and visual impact in seaport cities	0.916							
F43	Environmental politics	0.899							
F44	Reduction of congestion and CO2 emissions	0.845							

Source(s): The authors

Table 3.

serve to disrupt dry port operations. "Economic" was also identified as a risk dimension (sixth). These are risks that touch upon potential adverse changes in economic circumstances. They are important because dry ports are of significant national economic importance (Khaslavskaya and Roso, 2020).

We identified the seventh dimension as "*political and social*" imperatives. These are risks that are predominantly associated with changes in the national power structures of government. Political risks arise primarily because dry ports serve a significant economic function as major trade gateways. Dry ports can also serve a social role by creating employment opportunities, which are critical for economic and social development (Xiahou et al., 2018). The final risk dimension was "*environment*." Dry ports and railway connections offer significant environmental benefits, particularly in reducing congestion and associated carbon emissions, making them a critical component of the sustainability efforts of any country (Varese et al., 2022; Beyene et al., 2023).

4.2 Risk interdependency, heterogeneity and priority

On the basis of the fuzzy-based DEMATEL, the total effects for risk dimensions, as ordered by (1) "DPE," (2) "customers," (3) "FRS" and (4) aggregated by all stakeholders are shown in Table 4.

The total effect from the "DPE" perspective indicates that D1, D3, D2 and D5 were the most prominent effect dimensions, and D6, D7 and D8 were classified as cause dimensions.

Table 4.
Total effects given and
received by risk
dimensions

Dimension	Code	R	C	Fuzzy	R + C	RC	Crisp		Role
							R + C	RC	
i) Dry port entities (DPE)									
Cost	D1	(0.83; 2.24; 9.74)	(0.99; 2.52; 10.26)	(1.83; 4.76; 20.01)		(-9.43; -0.28; 8.74)	7.19	-0.31	Effect
Location	D2	(0.80; 2.19; 9.54)	(0.85; 2.26; 9.78)	(1.66; 4.45; 19.33)		(-8.97; -0.07; 8.69)	6.86	-0.14	Effect
Infrastructural	D3	(0.82; 2.21; 9.61)	(0.85; 2.27; 9.77)	(1.67; 4.48; 19.38)		(-8.95; -0.05; 8.76)	6.89	-0.11	Effect
Accessibility	D4	(0.76; 2.10; 9.32)	(0.76; 2.11; 9.49)	(1.53; 4.21; 18.81)		(-8.72; -0.01; 8.55)	6.61	-0.08	Effect
Operational	D5	(0.75; 2.07; 9.23)	(0.82; 2.23; 9.65)	(1.58; 4.30; 18.88)		(-8.89; -0.15; 8.40)	6.68	-0.21	Effect
Economic	D6	(0.79; 2.15; 9.47)	(0.71; 2.03; 9.24)	(1.51; 4.18; 18.72)		(-8.44; 0.12; 8.76)	6.57	0.06	Cause
Political and social	D7	(0.61; 1.83; 8.80)	(0.49; 1.62; 8.23)	(1.11; 3.46; 17.04)		(-7.61; 0.21; 8.31)	5.76	0.17	Cause
Environment	D8	(0.61; 1.85; 8.86)	(0.49; 1.60; 8.17)	(1.10; 3.45; 17.03)		(-7.55; 0.24; 8.36)	5.75	0.21	Cause
ii) Customers									
Cost	D1	(0.87; 2.50; 12.93)	(1.06; 2.86; 13.78)	(1.93; 5.37; 26.71)		(-12.9; -0.35; 11.86)	8.86	-0.4	Effect
Location	D2	(0.85; 2.47; 12.91)	(0.94; 2.64; 13.45)	(1.80; 5.12; 26.37)		(-12.6; -0.16; 11.96)	8.61	-0.24	Effect
Infrastructural	D3	(0.84; 2.46; 12.82)	(0.91; 2.59; 13.41)	(1.76; 5.06; 26.24)		(-12.5; -0.12; 11.90)	8.55	-0.22	Effect
Accessibility	D4	(0.84; 2.45; 12.93)	(0.83; 2.43; 12.89)	(1.68; 4.88; 25.82)		(-12.0; 0.02; 12.10)	8.35	-0.03	Effect
Operational	D5	(0.87; 2.51; 13.11)	(0.88; 2.54; 13.24)	(1.76; 5.05; 26.36)		(-12.3; -0.03; 12.22)	8.56	-0.09	Effect
Economic	D6	(0.84; 2.45; 12.94)	(0.83; 2.44; 13.01)	(1.67; 4.89; 25.95)		(-12.1; 0.01; 12.11)	8.38	-0.06	Effect
Political and social	D7	(0.76; 2.31; 12.54)	(0.57; 1.94; 11.49)	(1.34; 4.25; 24.03)		(-10.7; 0.36; 11.97)	7.59	0.34	Cause
Environment	D8	(0.75; 2.26; 12.49)	(0.61; 1.99; 11.38)	(1.36; 4.25; 23.88)		(-10.6; 0.27; 11.88)	7.58	0.29	Cause
iii) Federal revenue superintendence (FRS)									
Cost	D1	(0.52; 1.35; 6.99)	(0.64; 1.57; 7.42)	(1.16; 2.92; 14.41)		(-6.89; -0.21; 6.35)	4.8	-0.22	Effect
Location	D2	(0.38; 1.16; 6.48)	(0.47; 1.30; 6.80)	(0.86; 2.47; 13.28)		(-6.41; -0.14; 6.00)	4.28	-0.16	Effect
Infrastructural	D3	(0.58; 1.44; 7.15)	(0.54; 1.40; 7.09)	(1.12; 2.84; 14.24)		(-6.50; 0.04; 6.61)	4.72	0.01	Cause
Accessibility	D4	(0.42; 1.20; 6.43)	(0.47; 1.30; 6.85)	(0.90; 2.51; 13.28)		(-6.42; -0.10; 5.95)	4.32	-0.15	Effect
Operational	D5	(0.51; 1.34; 6.88)	(0.53; 1.39; 7.11)	(1.05; 2.73; 14.00)		(-6.60; -0.05; 6.34)	4.6	-0.09	Effect
Economic	D6	(0.38; 1.13; 6.27)	(0.28; 0.99; 5.99)	(0.66; 2.12; 12.26)		(-5.60; 0.14; 5.99)	3.86	0.12	Cause
Political and social	D7	(0.26; 1.01; 6.02)	(0.09; 0.67; 4.97)	(0.36; 1.68; 10.99)		(-4.70; 0.33; 5.92)	3.3	0.36	Cause
Environment	D8	(0.10; 0.70; 5.08)	(0.13; 0.70; 5.07)	(0.23; 1.41; 10.16)		(-4.97; 0.00; 4.95)	2.94	-0.02	Effect
iv) Dimensions aggregated									
Cost	D1	(0.74; 2.03; 9.91)	(0.89; 2.31; 10.51)	(1.64; 4.34; 20.42)		(-9.76; -0.28; 9.01)	6.95	-0.31	Effect
Location	D2	(0.68; 1.94; 9.67)	(0.75; 2.06; 10.02)	(1.43; 4.00; 19.70)		(-9.34; -0.12; 8.91)	6.59	-0.18	Effect
Infrastructural	D3	(0.75; 2.04; 9.89)	(0.76; 2.08; 10.10)	(1.51; 4.12; 19.99)		(-9.35; -0.04; 9.12)	6.72	-0.11	Effect
Accessibility	D4	(0.67; 1.91; 9.58)	(0.68; 1.94; 9.75)	(1.36; 3.86; 19.34)		(-9.08; -0.02; 8.89)	6.42	-0.09	Effect
Operational	D5	(0.71; 1.97; 9.76)	(0.75; 2.05; 10.03)	(1.46; 4.02; 19.79)		(-9.31; -0.08; 9.01)	6.62	-0.14	Effect
Economic	D6	(0.67; 1.91; 9.59)	(0.61; 1.81; 9.43)	(1.28; 3.73; 19.02)		(-8.76; 0.09; 8.97)	6.28	0.03	Cause
Political and social	D7	(0.54; 1.70; 9.13)	(0.38; 1.41; 8.24)	(0.93; 3.11; 17.37)		(-7.69; 0.29; 8.74)	5.54	0.28	Cause
Environment	D8	(0.48; 1.59; 8.81)	(0.41; 1.43; 8.24)	(0.89; 3.03; 17.06)		(-7.76; 0.16; 8.40)	5.43	0.14	Cause
Source(s): The authors									

Source(s): The authors

From the “customers” perspective, the most prominent effect dimensions are D1, D2, D5 and D4, with D7 and D8 emerging as cause dimensions. Regarding the “FRS” perspective, D1, D3, D5 and D4 are the most prominent effect dimensions associated with dry port projects, while D6 and D7 are categorized as cause dimensions. The results point to some incongruences in the risk perception among stakeholders. To summarize the results for all three groups of stakeholders, the total-influence fuzzy matrix $\tilde{T}$ was aggregated, highlighting D1, D3, D5 and D2 as the most prominent effect dimensions for dry ports projects. However, these dimensions are also affected by D6, D7 and D8, which are classified as key cause dimensions.

The result of the net influence matrices for each stakeholder group is shown in Table 5. These matrices illustrate the influences of risk dimensions listed by row relative to those listed by column. Positive values indicate influences of row dimensions on column dimensions, while negative values indicate influences in the reverse direction. Values highlighted in grey indicate influence above the net influence value averages, which are 0.029 for DPE, 0.042 for “customer,” 0.023 for FRS and 0.0305 for the “aggregated” result.

Based on our analysis of the IRM, which sought to map the dataset of prominence (R + C) and relation (R - C), Figure 2 (a), (b), (c) and (d) present the IRMs for “DPE,” “customers,”

Dimension	DPE								Customer							
	D1	D2	D3	D4	D5	D6	D7	D8	D1	D2	D3	D4	D5	D6	D7	D8
D1	-								-							
D2	0.024	-							0.024	-						
D3	0.031	0.012	-						0.030	0.008	-					
D4	0.027	0.012	0.004	-					0.050	0.030	0.032	-				
D5	0.021	-0.008	-0.004	-0.019	-				0.049	0.023	0.024	-0.003	-			
D6	0.053	0.028	0.033	0.021	0.038	-			0.054	0.027	0.025	0.001	0.014	-		
D7	0.064	0.037	0.036	0.035	0.049	0.021	-		0.098	0.078	0.075	0.052	0.058	0.057	-	
D8	0.067	0.051	0.047	0.043	0.055	0.023	0.000	-	0.089	0.071	0.066	0.050	0.053	0.048	0.000	-

Dimension	FRS								Aggregated							
	D1	D2	D3	D4	D5	D6	D7	D8	D1	D2	D3	D4	D5	D6	D7	D8
D1	-								-							
D2	0.010	-							0.020	-						
D3	0.028	0.020	-						0.030	0.013	-					
D4	-0.003	0.007	-0.020	-					0.025	0.017	0.006	-				
D5	0.025	0.023	-0.006	-0.002	-				0.031	0.012	0.004	-0.009	-			
D6	0.059	0.045	0.021	0.032	0.037	-			0.054	0.032	0.025	0.017	0.030	-		
D7	0.086	0.081	0.029	0.061	0.058	0.044	-		0.081	0.064	0.046	0.048	0.054	0.039	-	
D8	0.018	-0.005	-0.005	0.026	0.011	0.004	-0.039	-	0.056	0.037	0.034	0.037	0.039	0.024	-0.013	-

Source(s): The authors

Table 5.
Net influence matrices
by each
stakeholder group

“FRS” and “aggregated,” respectively, dividing the graph into four quadrants by the mean of $(R + C)$ and $(R - C)$:

- (1) Risk dimensions in quadrant “I” are identifiable as core dimensions since they have high “prominence” and “relation” significance;
- (2) Risk dimensions in quadrant “II” are identifiable as driving dimensions because they have low “prominence” but high “relation” significance;
- (3) Risk dimensions in quadrant “III” are low in both “prominence” and “relation” significance and are therefore relatively disconnected from the mapped system and
- (4) Risk dimensions in quadrant “IV” have high “prominence” but low “relation” significance, which means they are impacted by relatively heterogeneous dimensions and therefore cannot be directly improved through specific and focused managerial interventions (Si *et al.*, 2018).

To draw the net influence on IRM, represented by the blue arrows, twice the average net influence values were used as the threshold for building each net influence matrix: 0.057 for “DPE”, 0.084 for “customer”, 0.046 for “FRS” and 0.061 for “aggregated.” This representation enriches the IRM visualization by highlighting the dimensions that most affect others on the net. It is intended to emphasize what should weigh most on the minds of practitioners. Accordingly, Figure 2 summarizes the prominence and relation levels, as well as the most important net influences, for each risk dimension (addressing RQ2).

The IRM also offers a visualization of the heterogeneity of the risk perspective among the different groups of stakeholders (addressing RQ3). Figure 2(a) and 2(b) unveil similarities in “prominence” and “relation” between the DPE and customers stakeholder groups, showcasing how “political and social” and “environment” primarily impact “cost.” Additionally, dimensions in the Quadrant IV indicate those dimensions influenced by the others, emphasizing the need for a systematic approach to risk assessment.

Table 6 demonstrates that, in terms of prominence, the “DPE” stakeholder group identifies “cost,” “infrastructure” and “location” as the most important dimensions, respectively. At the same time, the “FRS” stakeholder group also prioritizes “cost” and

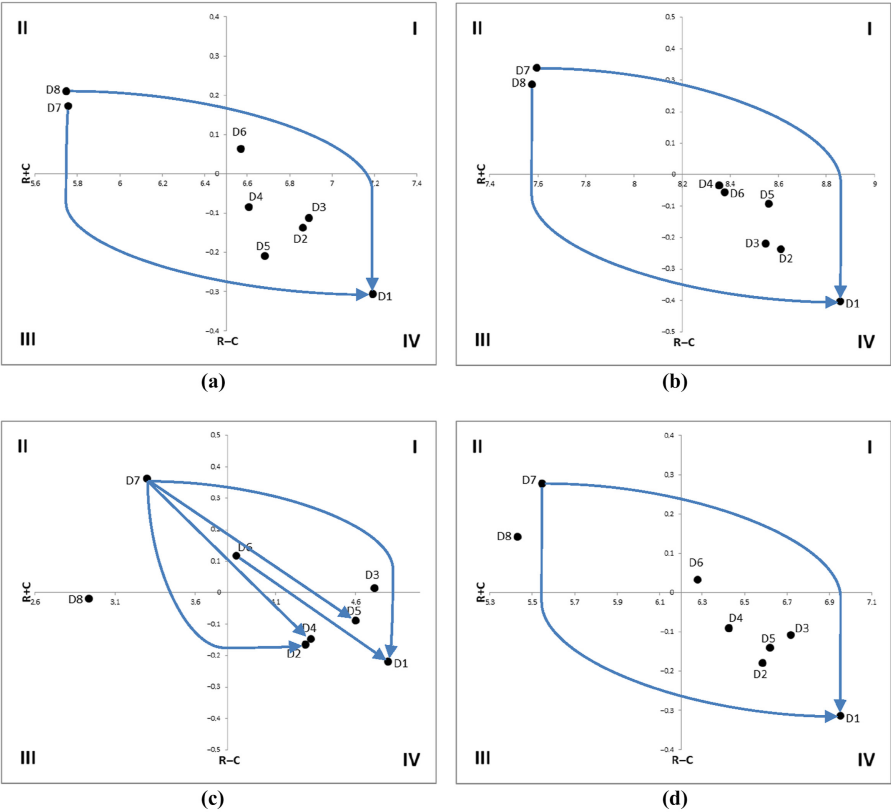


Figure 2.
Influential relation map

Source(s): The authors

“infrastructure,” while the “customers” group emphasize “location” as the second most important dimension. From an aggregated perspective, the “operational” dimension emerges as the third most important risk dimension.

5. Discussion

Our study commenced with the identification of 44 dry port risk factors that were subsequently aggregated into 8 primary latent risk dimensions (RQ1). Awareness of these identified risk factors presents a level of granularity that will aid different aspects of risk management, especially its analysis, evaluation and treatment. Drawing from Marshall *et al.* (2019), these aggregated risk dimensions may serve as the first major step toward developing a comprehensive template for concrete risk knowledge in dry ports. Reducing the risk factors into dimensions will prove to be further important for relevant decision-making. In particular, it enables a more straightforward understanding of risk patterns, allowing managers to develop deeper insights and make informed decisions based on stakeholder expectations and interests (Bjornsen and Aven, 2019).

Finding “cost” as the most significant risk dimension for dry port projects is consistent with existing dry port literature (Lirn and Wong, 2013; Chang *et al.*, 2019). It is also consistent with the wider literature on major infrastructure projects (e.g. Caffieri *et al.*, 2018). With an appreciation

Risk dimension	R + C				R - C			
	DPE	Rank	Customer	Rank	FRS	Rank	Customer	Rank
Cost	D1	7.19	1	4.8	1	6.95	8	8
Location	D2	6.86	3	4.28	5	6.59	6	7
Infrastructure	D3	6.89	2	4.72	2	6.72	5	3
Accessibility	D4	6.61	5	4.32	4	6.42	4	6
Operational	D5	6.68	4	4.6	3	6.62	3	5
Economic	D6	6.57	6	3.86	6	6.28	7	4
Political and social	D7	5.76	8	3.3	7	5.54	2	1
Environment	D8	5.75	7	2.94	8	5.43	1	2
Source(s): The authors								

Table 6.
Prioritization of risk
dimensions by
stakeholders groups

that costs are the core foundation of economic thinking, featuring as a key element of assessment of economic outcomes, this finding serves to reiterate that the decision to develop and operate a dry port must be one not taken lightly. In further finding “cost” as most influenced by other dimensions, particularly the “*economic*,” “*political and social*” and “*environment*” dimensions, our finding serves as a restatement of its central role in economic, political/social and environmental ways of thinking about their development and operations (RQ2).

The dynamic nature of the risk dimensions emphasizes their heterogeneity based on the perspectives of different stakeholders. Whether these stakeholders share common goals or have conflicting interests, it is evident that the interconnectedness of the risk dimensions presents an opportunity for collaboration. By recognizing these interdependencies, stakeholders can foster a cooperative environment where the impact of each risk dimension on others is carefully assessed and managed. Such collaboration not only enhances the value proposition for all involved parties but also serves to ensure the success of dry port projects. This may be pertinent as the study findings suggest congruences and divergences in the perception of risk among the different stakeholder groups (RQ3).

For example, congruence was observed between “*dry port entities*” and “*customers*” groups. Considering “*customers*” as shippers and consignees who import and export containerized cargo and “*dry port entities*” as logistical operators that offer services to facilitate this process, congruence in risk perception may help build a collaborative environment for dry port project development. Despite the “Federal Revenue Superintendence” (FRS) being associated with divergent perspectives, as a regulatory agent, this information may also prove useful in preventing development and eventual operational failures by communicating the priorities that should be considered, thus preventing regulatory problems during ongoing operations.

Taking all the above into consideration, the identified risk factors and dimensions may serve as the basis for re-channeling risk management efforts towards more proactivity in exploring a complex risk ecosystem that is typically the case in dry ports. Herein, we opine that the transfer of what is in effect abstract risk knowledge (i.e. the knowledge we have about dry port risks as gleaned from literature) into concrete risk knowledge (i.e. the knowledge we have about dry port risks as gleaned from our empirical study) enhances our ability to develop a comprehensive risk-management template that is capable of superior capability when engaging in the threats dry ports are most susceptible to.

Of particular relevance is our willingness to dispel what is a dominant traditional approach to previous studies looking to examine dry port risks. Aside from stakeholder heterogeneity and multiplicity, the reality is that risk management in dry ports can be further complexified by the peculiarities of risks. In practice, most risk dimensions are interdependent (Li *et al.*, 2019). However, while conventional risk management still widely assumes that risks are independent, the lack of ability to capture the nature of direct and indirect relationships between risk factors and dimensions potentially limits risk management efficacy. While we acknowledge that reliability practices may already be engaging in enabling risk identification and prioritization, surfacing these risk interdependencies in a timely manner and grounded in everyday dry port practice allows for more aptness to effective strategy formulation and the development of eventual successful operations of dry ports in a manner that will aid managers in mitigating and managing relevant risks.

6. Conclusions

Our study makes a contribution to management and theory. In terms of management practice, our study offers valuable insights on risk factors and dimensions most commonly engaged in dry port projects that transcend Brazilian boundaries, particularly in the global south. Brazil’s dry port challenges mirror some of those being experienced by countries such

as China, South Africa and the United Arab Emirates, which have a keen interest in expanding their dry port footprint. On this basis, our findings have the potential to resonate across these countries. Insights gleaned from our study can also be leveraged to potentially offer a broad roadmap for effective risk management across the domain of multistakeholder infrastructure projects. By systematically analyzing risk factors, aggregating them into key dimensions and prioritizing them based on stakeholder perspectives, project managers working on these projects can potentially enhance decision-making processes, allocate resources more efficiently and drive more collaborative risk management efforts.

Our study also makes theoretical contributions to the field of risk management, particularly in the context of dry ports. Firstly, by elucidating the interdependencies among various risk dimensions, we have contributed to an advanced understanding of the complex stakeholder dynamics inherent in multistakeholder infrastructure projects. Our study also makes a contribution to the broader literature on stakeholder literature by underscoring the importance of considering diverse stakeholder perspectives in risk prioritization and management.

As expected, our study has some limitations. First, we did not consider probability and impact in the analysis of risk dimensions. This may have implications for the accuracy and comprehensiveness of the risk assessment. Furthermore, the study is subject to limitations associated with the methodologies employed, particularly EFA and DEMATEL. For example, EFA, while useful for identifying underlying factors within a dataset, relies on subjective interpretation and may overlook certain nuances or interrelationships among variables. Similarly, DEMATEL, despite its utility in exploring causal relationships among factors, may be influenced by the biases of the experts involved in the process and may not capture the full complexity of stakeholder interactions and risk interdependencies in dry port projects. Additionally, it is worth noting that a variety of risk events that may reflect the risk factors were not listed in the study, with their inclusion varying according to the specifics of each case. Therefore, the reliance on these methodologies suggests the need for caution in interpreting the results and underscores the importance of exploring alternative approaches to enhance the robustness of risk assessment in the context of dry port projects.

Finally, as a call for future research, there is a critical need to focus on designing and exploring risk category architectures with efficiency in mind, particularly for collaborative project risk management in dry ports. Perhaps most importantly, there is a potential for future studies with an expanded stakeholder grouping. While we have adopted a stakeholder grouping that resonates with prior studies, it may be beneficial to undertake future studies with a more granular grouping of stakeholders. Future studies may also be undertaken in a comparative manner that is able to explore potential similarities and differences in risk factors and dimensionality. Such cross-country comparisons will enable more valuable insights into the effectiveness of different risk identification, prioritize and management strategies.

References

- Al-Mazrouie, J., Ojiako, U., Williams, T., Chipulu, M. and Marshall, A. (2021), "An operations readiness typology for mitigating against transitional 'disastrous openings' of airport infrastructure projects", *Production Planning and Control*, Vol. 32 No. 4, pp. 283-302, doi: [10.1080/09537287.2020.1730997](https://doi.org/10.1080/09537287.2020.1730997).
- Alam, J. (2016), "Role of effective planning process in boosting dry port effectiveness: a case study of central Pakistan", *International Journal of Supply Chain Management*, Vol. 5 No. 3, pp. 153-164.
- Beyene, Z., Nadeem, S., Jaleta, M. and Kreie, A. (2023), "Research trends in dry port sustainability: a bibliometric analysis", *Sustainability*, Vol. 16, pp. 1-21, doi: [10.3390/su16010263](https://doi.org/10.3390/su16010263).

- Bjørnsen, K. and Aven, T. (2019), "Risk aggregation: what does it really mean?", *Reliability Engineering and System Safety*, Vol. 191, pp. 1-5.
- Brazilian Suppliers (2020), "Brazilian directory of exporting commercials", available at: <http://www.braziliansuppliers.com.br/busca> (accessed 24 January 2020).
- Bryde, D., Shahgholian, A., Joby, R., Taylor, S. and Singh, R. (2023), "Impact pathways: managing relational risk in project operations", *International Journal of Operations and Production Management*, Vol. 43 No. 9, pp. 1481-1488, doi: [10.1108/ijopm-08-2022-0484](https://doi.org/10.1108/ijopm-08-2022-0484).
- Caffieri, J., Love, P., Whyte, A. and Ahiaga-Dagbui, D. (2018), "Planning for production in construction: controlling costs in major capital projects", *Production Planning and Control*, Vol. 29 No. 1, pp. 41-50, doi: [10.1080/09537287.2017.1376258](https://doi.org/10.1080/09537287.2017.1376258).
- Catve (2020), "Judge decides to close CODAPAR dry port", available at: <https://encurtador.com.br/bcyKS> (accessed 28 November 2020).
- Chang, C., Xu, J., Dong, J. and Yang, Z. (2019), "Selection of effective risk mitigation strategies in container shipping operations", *Maritime Business Review*, Vol. 4 No. 4, pp. 413-431, doi: [10.1108/mabr-04-2019-0013](https://doi.org/10.1108/mabr-04-2019-0013).
- Chipulu, M., Ojiako, U., Marshall, A., Williams, T., Bititci, U., Mota, C., Shou, Y., Thomas, A., Dirani, A.E., Maguire, S. and Stamati, T. (2019), "A dimensional analysis of stakeholder assessment of project outcomes", *Production Planning and Control*, Vol. 30 No. 13, pp. 1072-1090, doi: [10.1080/09537287.2019.1567859](https://doi.org/10.1080/09537287.2019.1567859).
- CIA (2020), "The world factbook: Brazil", available at: <https://www.cia.gov/library/publications/the-world-factbook/geos/br.html> (accessed 8 June 2020).
- CIB (2016), "Catalog of Brazilian importers", available at: <https://cib.dpr.gov.br/> (accessed 24 January 2020).
- Ciortescu, C. and Păvălașcu, N. (2012), "Managing risks in dry port operations", *Ovidius University Annals*, Vol. 12, pp. 851-855.
- Dadvar, E., Ganji, S. and Tanzifi, M. (2011), "Feasibility of establishment of 'Dry Ports' in the developing countries – the case of Iran", *Journal of Transportation Security*, Vol. 4 No. 1, pp. 19-33, doi: [10.1007/s12198-010-0056-x](https://doi.org/10.1007/s12198-010-0056-x).
- Doyle, J., Ojiako, U., Marshall, A., Dawson, I. and Brito, M. (2020), "The anchoring heuristic and overconfidence bias among frontline employees in supply chain organisations", *Production Planning and Control*, Vol. 32 No. 7, pp. 549-566, doi: [10.1080/09537287.2020.1744042](https://doi.org/10.1080/09537287.2020.1744042).
- Field, A. (2013), *Discovering Statistics Using IBM SPSS Statistics*, 4th ed., Sage, London.
- Hsu, W., Wei, Y., Lee, C.H., Hoang, L. and Huynh, N. (2023), "A risk assessment model of work safety in container dry ports", *Proceedings of the Institution of Civil Engineers-Maritime Engineering*, Vol. 176 No. 4, pp. 193-205, doi: [10.1680/jmaen.2022.006](https://doi.org/10.1680/jmaen.2022.006).
- Jeevan, J. (2016), "The role of Malaysian dry ports in the container seaport system", PhD thesis, University of Tasmania, available at: https://figshare.utas.edu.au/articles/thesis/The_role_of_Malaysian_dry_ports_in_the_container_seaport_system/23239970 (accessed 14 May 2023).
- Jeevan, J., Salleh, N., Loke, K. and Saharuddin, A. (2017), "Preparation of dry ports for a competitive environment in the container seaport system: a process benchmarking approach", *International Journal of E-Navigation and Maritime Economy*, Vol. 7, pp. 19-33, doi: [10.1016/j.enavi.2017.06.003](https://doi.org/10.1016/j.enavi.2017.06.003).
- Jeevan, J., Rahadi, R., Mohamed, M., Salleh, N., Othman, M. and Ruslan, S. (2022), "Revisiting the marketing approach between seaports and dry ports in Malaysia: current trend and strategy for improvement", *Maritime Business Review*, Vol. 8 No. 2, pp. 101-120, doi: [10.1108/mabr-09-2020-0060](https://doi.org/10.1108/mabr-09-2020-0060).
- Khan, S., Haleem, A. and Khan, M. (2021), "Risk management in Halal supply chain: an integrated fuzzy Delphi and DEMATEL approach", *Journal of Modelling in Management*, Vol. 16 No. 1, pp. 172-214, doi: [10.1108/jm2-09-2019-0228](https://doi.org/10.1108/jm2-09-2019-0228).

- Khaslavskaya, A. and Roso, V. (2020), "Dry ports: research outcomes, trends, and future implications", *Maritime Economics and Logistics*, Vol. 22 No. 2, pp. 265-292, doi: [10.1057/s41278-020-00152-9](https://doi.org/10.1057/s41278-020-00152-9).
- Khompapatporn, C. and Somboonwiwat, T. (2017), "Causal factor relations of supply chain competitiveness via fuzzy DEMATEL method for Thai automotive industry", *Production Planning and Control*, Vol. 28 Nos 6-8, pp. 538-551, doi: [10.1080/09537287.2017.1309713](https://doi.org/10.1080/09537287.2017.1309713).
- Kwateng, K., Donkoh, A. and Muntaka, A. (2017), "Evaluation of dry port implementation in Ghana", *Maritime Business Review*, Vol. 2 No. 3, pp. 261-278, doi: [10.1108/mabr-01-2017-0005](https://doi.org/10.1108/mabr-01-2017-0005).
- Lättilä, L., Henttu, V. and Hilmola, O. (2013), "Hinterland operations of seaports do matter: dry port usage effects on transportation costs and CO2 emissions", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 55, pp. 23-42, doi: [10.1016/j.tre.2013.03.007](https://doi.org/10.1016/j.tre.2013.03.007).
- Li, J., Zhang, J. and Sua, W. (2019), "Risk assessment in cross-border transport infrastructure projects: a fuzzy hybrid method considering dual interdependent effects", *Information Sciences*, Vol. 488, pp. 140-157, doi: [10.1016/j.ins.2019.03.028](https://doi.org/10.1016/j.ins.2019.03.028).
- Lirn, T. and Wong, R. (2013), "Determinants of grain shippers' and importers' freight transport choice behavior", *Production Planning and Control*, Vol. 24 No. 7, pp. 575-588, doi: [10.1080/09537287.2012.659868](https://doi.org/10.1080/09537287.2012.659868).
- Machiels, T., Compennolle, T. and Coppens, T. (2023), "Stakeholder perceptions of uncertainty matter in megaprojects: the Flemish A102 infrastructure project", *International Journal of Project Management*, Vol. 41, pp. 1-12, doi: [10.1016/j.ijproman.2023.102437](https://doi.org/10.1016/j.ijproman.2023.102437).
- Mangla, S., Luthra, S., Jakhar, S., Tyagi, M. and Narkhede, B. (2018), "Benchmarking the logistics management implementation using Delphi and fuzzy DEMATEL", *Benchmarking: An International Journal*, Vol. 25 No. 6, pp. 1795-1828, doi: [10.1108/bij-01-2017-0006](https://doi.org/10.1108/bij-01-2017-0006).
- Marshall, A. and Ojiako, U. (2013), "Managing risk through the veil of ignorance", *Journal of Risk Research*, Vol. 16 No. 10, pp. 1225-1239, doi: [10.1080/13669877.2013.788056](https://doi.org/10.1080/13669877.2013.788056).
- Marshall, A., Ojiako, U., Wang, V., Lin, F. and Chipulu, M. (2019), "Forecasting unknown/unknowns by boosting the risk radar within the risk intelligent organization", *International Journal of Forecasting*, Vol. 35 No. 2, pp. 644-658, doi: [10.1016/j.ijforecast.2018.07.015](https://doi.org/10.1016/j.ijforecast.2018.07.015).
- Miraj, P., Berawi, M., Zagloel, T., Sari, M. and Saroji, G. (2021), "Research trend of dry port studies: a two-decade systematic review", *Maritime Policy and Management*, Vol. 48 No. 4, pp. 563-582, doi: [10.1080/03088839.2020.1798031](https://doi.org/10.1080/03088839.2020.1798031).
- Ng, A., Padilha, F. and Pallis, A. (2013), "Institutions, bureaucratic and logistical roles of dry ports: the Brazilian experiences", *Journal of Transport Geography*, Vol. 27, pp. 46-55, doi: [10.1016/j.jtrangeo.2012.05.003](https://doi.org/10.1016/j.jtrangeo.2012.05.003).
- Nguyen, L. and Notteboom, T. (2016), "A multi-criteria approach to dry port location in developing economies with application to Vietnam", *Asian Journal of Shipping and Logistics*, Vol. 32 No. 1, pp. 23-32, doi: [10.1016/j.ajsl.2016.03.003](https://doi.org/10.1016/j.ajsl.2016.03.003).
- Nguyen, S., Chen, P. and Du, Y. (2022), "Container shipping operational risks: an overview of assessment and analysis", *Maritime Policy and Management*, Vol. 49 No. 2, pp. 279-299, doi: [10.1080/03088839.2021.1875142](https://doi.org/10.1080/03088839.2021.1875142).
- Opricovic, S. and Tzeng, G. (2003), "Defuzzification within a multicriteria decision model", *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, Vol. 11 No. 05, pp. 635-652, doi: [10.1142/s0218488503002387](https://doi.org/10.1142/s0218488503002387).
- Rodrigue, J. and Notteboom, T. (2022), *Port Economics, Management and Policy*, 1st ed., Routledge, NY.
- Rodrigues, T., Mota, C., Ojiako, U. and Dweiri, F. (2021a), "Assessing the objectives of dry ports: main issues, challenges and opportunities in Brazil", *International Journal of Logistics Management*, Vol. 32 No. 1, pp. 237-261, doi: [10.1108/ijlm-10-2020-0386](https://doi.org/10.1108/ijlm-10-2020-0386).
- Rodrigues, T., Mota, C. and Santos, I. (2021b), "Determining dry port criteria that support decision making", *Research in Transportation Economics*, Vol. 88, pp. 1-10.

- Rodrigues, T., Mota, C., Ojiako, U., Chipulu, M., Marshall, A. and Dweiri, F. (2023a), "A flexible cost model for seaport-hinterland decisions in container shipping", *Research in Transportation Business and Management*, Vol. 49, 101016, pp. 1-18.
- Rodrigues, T., Mota, C., Ojiako, U., Chipulu, M., Marshall, A. and Dweiri, F. (2023b), "Competitiveness throughout the seaport-hinterland: a container shipping analysis", *Maritime Policy and Management*, pp. 1-20, doi: [10.1080/03088839.2023.2248125](https://doi.org/10.1080/03088839.2023.2248125).
- Rodrigues, T., Ojiako, U., Marshall, A., Mota, C., Dweiri, F., Chipulu, M., Ika, L. and AlRaeesi, E. (2024), "Risk factor prioritization in infrastructure handover to operations", *International Journal of Project Management*, Vol. 42, pp. 1-18, doi: [10.1016/j.ijproman.2023.102558](https://doi.org/10.1016/j.ijproman.2023.102558).
- Roso, V. (2007), "Evaluation of the dry port concept from an environmental perspective: a note", *Transportation Research Part D*, Vol. 12 No. 7, pp. 523-527, doi: [10.1016/j.trd.2007.07.001](https://doi.org/10.1016/j.trd.2007.07.001).
- Roso, V. and Lumsden, K. (2010), "A review of dry ports", *Maritime Economics and Logistics*, Vol. 12 No. 2, pp. 196-213, doi: [10.1057/mel.2010.5](https://doi.org/10.1057/mel.2010.5).
- Si, S., You, X., Liu, H. and Zhang, P. (2018), "DEMATEL technique: a systematic review of the state-of-the-art literature on methodologies and applications", *Mathematical Problems in Engineering*, Vol. 2018, pp. 1-33, doi: [10.1155/2018/3696457](https://doi.org/10.1155/2018/3696457).
- Timmerman, M. and Lorenzo-Seva, U. (2011), "Dimensionality assessment of ordered polytomous items with parallel analysis", *Psychological Methods*, Vol. 16 No. 2, pp. 209-220, doi: [10.1037/a0023353](https://doi.org/10.1037/a0023353).
- UNCTAD (2022), "Review of maritime transport 2022", available at: https://unctad.org/system/files/official-document/rmt2022_en.pdf (accessed 2 January 2022).
- van Nguyen, T., Zhang, J., Zhou, L., Meng, M. and He, Y. (2020), "A data-driven optimization of large-scale dry port location using the hybrid approach of data mining and complex network theory", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 134, 101816, pp. 1-17, doi: [10.1016/j.tre.2019.11.010](https://doi.org/10.1016/j.tre.2019.11.010).
- Varese, E., Bux, C., Amicarelli, V. and Lombardi, M. (2022), "Assessing dry ports' environmental sustainability", *Environments*, Vol. 9, pp. 1-17, doi: [10.3390/environments9090117](https://doi.org/10.3390/environments9090117).
- Wang, C., Chen, Q. and Huang, R. (2017), "Locating dry ports on a network: a case study on Tianjin Port", *Maritime Policy and Management*, Vol. 45 No. 1, pp. 71-88, doi: [10.1080/03088839.2017.1330558](https://doi.org/10.1080/03088839.2017.1330558).
- Wang, B., Chin, K. and Su, Q. (2022a), "Risk management and market structures in seaport-dry port systems", *Maritime Economics and Logistics*, Vol. 24 No. 1, pp. 114-137, doi: [10.1057/s41278-021-00202-w](https://doi.org/10.1057/s41278-021-00202-w).
- Wang, B., Chin, K.S. and Su, Q. (2022b), "Prevention and adaptation to diversified risks in the seaport-dry port system under asymmetric risk behaviors: invest earlier or wait?", *Transport Policy*, Vol. 125, pp. 11-36, doi: [10.1016/j.tranpol.2022.05.006](https://doi.org/10.1016/j.tranpol.2022.05.006).
- Wide, P., Kalahasthi, L. and Roso, V. (2023), "Efficiency effects of information on operational disruption management in port hinterland freight transport: simulation of a Swedish dry port case", *International Journal of Logistics Research and Applications*, Vol. 26 No. 5, pp. 524-547, doi: [10.1080/13675567.2022.2100333](https://doi.org/10.1080/13675567.2022.2100333).
- Xiahou, X., Tang, Y., Yuan, J., Chang, T., Liu, P. and Li, Q. (2018), "Evaluating social performance of construction projects: an empirical study", *Sustainability*, Vol. 10 No. 7, pp. 1-16, doi: [10.3390/su10072329](https://doi.org/10.3390/su10072329).

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