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Dry ports: research outcomes, trends, and future implications

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Abstract

The concept of dry ports has gained significant interest among practitioners and researchers in the last decade. Consequently, publications on this topic have followed this development, and today there are more than 100 papers available in the Scopus and Science Direct databases, compared with only two papers in 2007. The purpose of this paper is to summarize current scientific knowledge on the phenomenon and to identify research outcomes, trends, and future research implications by conducting a systematic literature review (SLR). SLR is an explicit and reproducible method that ensures the reliability and traceability of the results. The selection of relevant papers was performed independently by each author using Rayyan QCRI software; the coding and analysis were conducted with the help of NVivo qualitative data analysis software. Findings show that the research area is largely represented by qualitative cases and optimization studies covering various aspects of dry ports. Dry port examples around the world differ based on location, functions, services, ownership, and maturity level. Although the research area is young and discrete, five main thematic areas are identified: debate on the concept, environmental impact, economic impact, performance impact, and dry ports from a network perspective.

Keywords Dry port · Intermodal transportation · Hinterland · Seaport inland access · Systematic literature review

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1 Introduction

The maritime leg of the intermodal transport chain uses larger ships to cope with the demand for increased containerized transport and to fully utilize economies of scale (Haralambides 2019). Consequently, seaports face challenges related to terminal capacity, fairway drafts, equipment to handle those vessels, and, in particular, challenges related to inland access. Despite heavy investments in container terminal capacity and equipment, larger ships and larger flows of containers exert a severe strain on seaports, and progress in seaport and hinterland operations must therefore match this growth. Efficient handling and distribution of cargo to and from the hinterland is crucial for the overall performance of seaports and for the whole supply chain. Research addressing the effect of hinterland distribution on seaport performance has gained importance in recent years (see, e.g., Haralambides 2017; Lättilä et al. 2013; Monios 2011). Efficiency in the hinterland part of transport chains has generally not mirrored the progress at sea. Hence, environmental problems related to the transport sector and the role that logistics systems can play in reducing environmental effects are garnering increasing attention. However, until recently, logistics concepts have not been extensively researched regarding their role in mitigating environmental impacts. One of the concepts with the potential to reduce environmental impacts related to the seaport transport system is the dry port.

The most widely used definition of a dry port is the one suggested by Roso et al. (2009): “A dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardised units as if directly to a seaport.” However, as noted by Rodrigue et al. (2010), “no two dry ports are the same.” Dry ports exist in very different forms and arrangements under different terms around the world, and they differ in location, functionality, maturity level, ownership, and initiation processes. Consequently, the research has branched out into different fields, resulting in a diversity of dry port publications using different research designs and focusing on different aspects of the same phenomenon. Therefore, the purpose of this paper is to summarize current scientific knowledge on the phenomenon and to identify research outcomes, trends, and future research implications by conducting a systematic literature review (SLR).

2 Methodology

2.1 Research design

A literature review serves as a tool for assessing and evaluating scientific knowledge in a particular research area and identifying potential gaps (Tranfield et al. 2003). Seuring et al. (2012) strongly recommend following a systematic method in conducting a review; otherwise the review may lack replicability and traceability. Compared with a classical (narrative) literature review, a systematic literature review (SLR) follows more rigorously predefined steps. Durach et al. (2017) reviewed core papers on SLR and proposed a guideline for conducting an SLR (Table 1). In addition, SLRs are often complemented with demographic data about the research



Table 1 Research design

Step (based on Durach et al. 2017)	Execution
(i) Defining the research question	What is the status of the current knowledge on dry ports? RQ1: What are the main thematic areas in the field? RQ2: What are the research findings? RQ3: What are the gaps, i.e., the potential for further research?
(ii) Determining the required characteristics of primary studies	Peer-reviewed academic publications on the subject of dry ports
(iii) Retrieving a sample of potentially relevant literature	Search in Scopus and ScienceDirect databases (see details below)
(iv) Selecting the pertinent literature	Exclusion of irrelevant items from the retrieved sample based on the following criteria: Wrong population (irrelevant) Background article Wrong publication type Foreign language Full text not available This step was conducted independently by each author using Rayyan QCRI software (Ouzzani et al. 2016)
(v) Synthesizing the literature	Bibliometric analysis: categorizing the selected research items into thematic areas/categories and synthesizing the knowledge on the phenomenon for each theme (RQ1)
(vi) Reporting the results	Reporting the results of the analysis and synthesis and answering RQ2 and RQ3

community (Seuring et al. 2012). The current review follows the steps synthesized by Durach et al. (2017) and suggestions made by Seuring et al. (2012), Table 1.

2.2 Retrieving relevant literature/search strategy

The search was conducted in Scopus and Science Direct databases in July 2019, and the filtering process was performed independently by each author using Rayyan QCRI software, as suggested by Ouzzani et al. (2016). The search string “dry port” OR “dry ports” OR “dryport*” OR “dry-port*” AND “transport*” was used for abstracts, keywords, and titles. The initial list (354 papers) was checked for duplicates; after the duplicates (35 papers) were eliminated/merged, the remaining research items (319 papers) were analyzed for relevance, first by screening the abstracts and then in some cases by screening the full text. At the same time, the research items not meeting the inclusion criteria were excluded. The detailed results of this screening process are presented in Table 2.

Most of the excluded items were those that did not correspond to the focus of our review; the remaining were excluded because they were considered to be background articles (relating to dry ports or mentioning the term “dry port” but not focusing on the phenomenon), they were of the wrong publication type (report, conference, or other than peer-reviewed type of publication) or written in a language other than English, or the full text of the item was not available.



Table 2 Inclusion/exclusion process

Parameter	Decision/result
Total number of research items retrieved from Scopus and Science Direct	$104 + 238 = 342$
After duplicates excluded	$342 - 35 = 307$
After abstract analysis	$307 - 214 = 93$
	Excluded:
	Wrong population (irrelevant) (193)
	Background article (9)
	Wrong publication type (7)
	Foreign language (3)
	Not available (2)
After full-text analysis	$93 - 3 = 90$
Cross-referencing added	$90 + 12 = 102$
Total	102

2.3 Analytical approach

The first step, bibliometric analysis, is related to general data regarding the research field and employs a quantitative approach to the research structure and development of the research field based on analysis of related publications. The second part of the analysis is content-based: the framework for this analysis evolves during the survey of the papers by identifying themes and coding them, and this review process is of an iterative nature. Already in the exclusion/inclusion process, Rayyan QCRI software facilitated the grouping of the selected papers according to thematic areas. As suggested by Agamez-Arias and Moyano-Fuentes (2017), we grouped the selected papers into subcategories (sub-lines) based on similar focus, and those subcategories were subsequently grouped into main categories (themes or main lines) of research based on their interrelationships. However, many papers had multiple areas of focus, and in those cases it was not possible to draw a sharp distinction; consequently, a paper could end up in a few categories. The content analysis of the selected papers was conducted with the aid of NVivo 11.4.3 qualitative research analysis software, which allowed us to create a database of all reviewed papers that facilitated the review process by providing easy access to the coded data.

3 Bibliometric aspects

The research on dry ports is new and emerging. It has grown from two journal publications in 2007 to over 100 a decade later. A search of the databases revealed the earliest item, dated 1984, referring to a similar phenomenon under the same term:



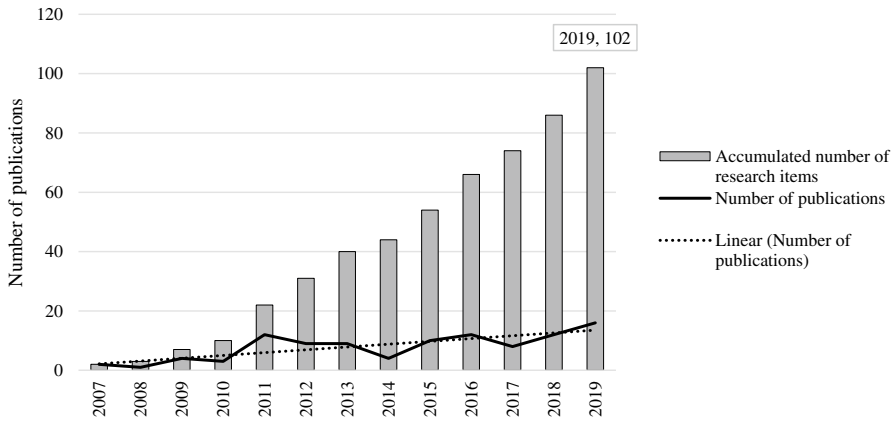


Fig. 1 Number of research items published per year

A proposal to establish the Port of Memphis as a dry port for New Orleans is presented. Export cargo in container would be assembled from all over the country at Memphis and then be carried to New Orleans by contract trains for shipment; the imported goods would be transported to Memphis for distribution. (“Memphis ‘dry port’ link to N.O. urged,” 1984).

The item itself was not available for review, and thus it is not included in this paper. However, the concept of a dry port was described in detail in an academic journal in 2009 (Roso et al. 2009), with several earlier publications referring to the term “dry port” but without explicitly defining it. Since then, interest in the topic has been evident within academia; the number of publications has grown every year (Fig. 1). The fall in the number of journal publications in 2014 may have resulted from the publication of two special issues in previous years. In addition, a book published in 2013 titled *Dry ports—a global perspective* contained 12 articles, all focused on dry ports and their application in different regions (Bergqvist et al. 2013). The book was not available in the reviewed databases and therefore was not included here, but the publishing of special issues and books in itself demonstrates the increasing interest in the subject.

Fifty-two journals published the reviewed articles, with the *Journal of Transport Geography* and *Transportation Research Part E* having the greatest share (Fig. 2). The former consists chiefly of papers using a qualitative approach and those dealing with the development of the concept and its application in different regions, while the latter covers mostly quantitative approaches on modeling and optimization of environmental and economic issues related to dry ports.

As the research focus of the studied papers varies, so do the methods applied. Most of the papers ($\approx 50\%$) used a case study and multiple cases as a research strategy, followed by modeling of either existing systems/cases or theoretical ones. With regard to data collection, most of the methods used were interviews and a mixture of secondary evidence such as trade journals, reports, previous studies, archives, and



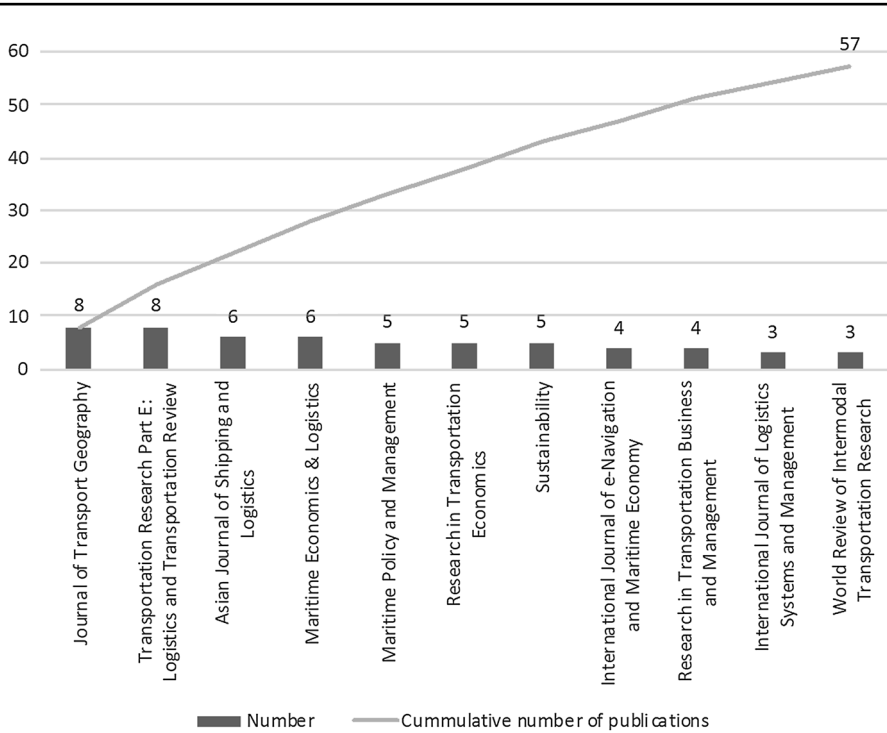


Fig. 2 Top-contributing journals

websites. Very few studies were based on observations, these usually in connection with interviews or site visits, and only about 10% were based on surveys. Overall, most of the papers do not provide a solid description of their methodology.

4 Research outcomes

Although the field of research is heterogeneous, the reviewed papers could be divided into broad thematic areas and further into subcategories; thematic analysis was therefore conducted. Identified thematic areas further analyzed include concept issues, environmental, economic, and performance impacts and network perspectives. Their subcategories are presented below.

4.1 Concept

4.1.1 Definition and taxonomy

Although the concept gained attention in academia about a decade ago, the setup of an intermodal terminal directly connected to a seaport existed long before. Nevertheless, in 2009, Roso et al. (2009) coined a dry port definition that was very



Table 3 Different dry port taxonomies

Classification criteria	Types of dry ports	References
Location and functions	Close, midrange, distant	Roso et al. (2009)
	Seaport-based, city-based, border	Beresford et al. (2012)
Development direction	Outside-in, inside-out	Wilmsmeier et al. (2011)
	Bidirectional	Added by Bask et al. (2014)
	Land-driven, sea-driven	Monios (2011)
Maturity level	Pre-, start-up, growth phase	Bask et al. (2014)
Dedication	Shared (or public), dedicated to particular enterprises or cargoes	Ng and Cetin (2012) and Feng et al. (2012)
Geography of operations	Domestic, international	Do et al. (2011)
Transportation mode	Rail-based, barge-based	Rodrigue and Notteboom (2012)

specific in meaning: “A dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their transshipment units as if directly to a seaport.” To meet the criteria of a dry port, an intermodal inland terminal facility should satisfy two parameters:

1. an inland extension of a seaport, i.e., serving as a seaport’s interface inland, offering services that are usually available at the seaport;
2. connection to a seaport by a “high-capacity transportation means,” which often implies rail and less frequently barge/inland waterway transportation.

However, there is still no definitive consensus about which term or definition to use for the facilities fitting the above description (Rodrigue et al. 2010). Nevertheless, the term “dry port” has been advocated by many researchers, as it captures the broad understanding scholars have regarding the concept (Witte et al. 2019). The review papers have suggested a number of dry port classifications, i.e., different taxonomies (Table 3).

Functions of dry ports vary depending on the type of facility, ranging from basic logistics services (e.g., transshipment, storage) to a variety of customer-oriented services including cargo consolidation and deconsolidation, maintenance and repair, track and trace, custom clearance, information processing and forwarding (Ng and Gujar 2009a, b; Beresford et al. 2012; Jeevan et al. 2015b). Dry port functions depend largely on the stakeholders involved, regulations, and relationships with seaports and the hinterland.

4.1.2 Development of the concept

Attempts to further develop the concept have been substantial. Veenstra et al. (2012) conceptualized the ability of a seaport to influence hinterland container flows and introduced the extended gate concept, where an “extended gate is an inland intermodal terminal directly connected to seaport terminal(s) with high capacity transport means, where customers can leave or pick up their transshipment units as if



directly with a seaport, *and where the seaport terminal can choose to control the flow of containers to and from the inland terminal*" (author's italics). The idea fits with the "outside-in" types of dry ports introduced earlier by Wilmsmeier et al. (2011), that is, dry port "developed by port authorities, port terminal operators or ocean carriers." Veenstra et al. (2012) conclude that "at a conceptual level, extended gates do not go beyond the dry port idea." Dry ports differ from other terminals chiefly by enabling high-capacity access to and from seaports. Rodrigue et al. (2010) elaborate using the term "inland port," which is widely used in the United States and better encompasses the relationship between seaport, inland terminals and logistics services. Further, Rodrigue and Notteboom (2012) discuss differences between dry ports in North America and Europe based on the features of transport/railway systems. A substantial portion of the reviewed publications deal with applications of the concept in different regions, including India (Haralambides and Gujar 2012), China (Beresford et al. 2012), South America, and Europe (Henttu and Hilmola 2011). Nguyen and Notteboom (2019) contributed to the generalization of knowledge on dry ports by identifying common patterns in a global selection of 107 dry ports. The authors established a correlation between seaport and dry port parameters, showing that dry port parameters are strongly related to the characteristics of the seaport served.

4.2 Environmental impact

Dry ports as elements of a hinterland distribution network stimulate a modal shift, which leads to less traffic and congestion at seaport gates and seaport cities, and reductions in emissions by as much as 32–45% (Lättilä et al. 2013). In seaport cities and regions, road congestion and associated costs of road accidents decrease. However, dry ports need to be integrated into seaport hinterland transportation systems, and transportation solutions should be favorable for stakeholders and supported by policies and regulations (Regmi and Hanaoka 2012).

Castagnetti (2012) discusses efforts to address environmental issues within the framework of European projects promoting the utilization of faster and heavier freight trains for hinterland distribution. Ng et al. (2013) touch upon the issue of how climate change may be considered in strategic plans of hinterland transportation nodes, i.e., seaports and dry ports. Environmental benefits are often discussed in the context of economic benefits. For example, a study conducted in Finland concludes that implementation of dry port networks would lead to a "reduction in both emissions and total transportation costs" (Henttu and Hilmola 2011). However, in cases of poor planning or failure to establish well-functioning transportation schedules between seaports and dry ports, emissions could increase rather than decrease (Hanaoka and Regmi 2011). Finally, attitudes towards environmental benefits vary much depending on the country: in India, where an oversupply of dry ports has been reported, public dry ports are focused on their own survival or, in other words, on maximizing profit, but not on reducing emissions. A similar situation is typical for publicly owned dry ports that "completely ignore CO₂ emission impacts" (Haralambides and Gujar 2012).



4.3 Economic impact

4.3.1 Regional development

Since a dry port should act as the seaport's inland interface, shifting port services to an inland region provides a stimulus for development and generates new employment (Ng and Tongzon 2010). Furthermore, regional development might positively influence competitiveness by maximizing the use of existing infrastructure and generating trade volumes. Ng and Tongzon (2010) went so far as to declare that dry ports were catalysts for regional development, at least in India. In the case of Iran, establishing a dry port in the province of Yazd could potentially increase freight transit in that country and influence development (Dorostkar et al. 2016).

4.3.2 Investments

Building new transport facilities requires significant financial investment and careful consideration of stakeholders' interests, but it also has the potential to provide numerous benefits. A number of parameters should be satisfied in order to establish a dry port. Implementation of the *extended gate* concept is seen as a good solution for ports in East Africa, but it would require a joint effort by multiple stakeholders involving planning and funding institutions, both private and governmental. Developing a dry port is an investment-intensive project in which there could be various options for obtaining funds. Public–private partnership (PPP) investment appears to be a viable model for the provision of necessary funds. This was discussed by Panova and Hilmola (2015), who compared dry port investment strategies in European countries to examples from New Zealand, India, and Turkey. They suggested PPP as the most convenient investment mechanism for funding dry port development in Russia. *Public investment* alone, on the other hand, may at times cause economic insolvency or excess capacity, as has been observed in certain cases in India (Haralambides and Gujar 2011). The authors conclude that PPP investments should be supported by governmental pricing policies and guidelines.

4.3.3 Feasibility of implementation

Lack of regulation, conflicting regulations, or regulations that have hindered the establishment of dry ports have often been cited in the literature. The feasibility of building dry ports in Iran was studied by Dorostkar et al. (2016), who showed that establishing rail shuttle services between potential dry ports and seaports was not realistic given the underdeveloped railway infrastructure. On the other hand, in the (former) Indochina area,¹ the implementation of dry ports is seen as a stimulus for the development of intermodal transportation. However, new challenges related to financing have arisen (Do et al. 2011). The major constraints on establishing dry ports in Russia are related to financing and investment risks (Panova and Korovyakovsky 2013).

¹ Today comprising Vietnam, Cambodia, and Laos.



4.3.4 Profitability

Implementation of dry ports can lead to an overall reduction in a country's transportation costs if an optimal number of facilities are put into operation in strategic locations (Henttu and Hilmola 2011). For example, in Finland, it was shown that the most significant cost reduction could be achieved by implementing a strategic number (4–6) of dry ports (Henttu et al. 2011). In Russia, the introduction of new dry ports could decrease the overall transit time of cargo through the Trans-Siberian Railway System (Panova 2011). Bergqvist et al. (2010) studied factors that influence the pace and process of dry port establishment, and their conclusions, based on two case studies in Sweden, presented a list of factors including the overall profitability of the project, location, presence of a “political entrepreneur,” and the presence of large local shippers. These are examples of general advantage/profitability related to the existence of dry ports in a transport system. More specific examples, for example, the profitability of specific services related—or available—to dry ports, can be found in Qiu et al. (2015), among others.

4.4 Performance impact

4.4.1 Dry port operations optimization

Studies have been conducted on optimization of dry port operations from different perspectives. Crainic et al. (2015) focus on the tactical level of transportation planning with the involvement of dry ports. Their model addresses the problem of optimizing a shuttle schedule between dry ports and seaports. A study by Chang et al. (2015) focuses on cost optimization for the stakeholders involved, including installation, storage, and transportation costs. Underperforming dry ports and dry ports facing operational issues are studied mainly in Asia. Ng and Gujar (2009a, b) study dry ports in India with a focus on regional development around dry ports, which could attract users. Value-added services offered at dry ports can make a region more attractive to the actors in the immediate vicinity, as well as attract potential new users from more remote locations. Jeevan et al. (2017) study Malaysian dry ports, identifying primary factors that influence their performance, such as information sharing, availability of value-added services such as customs clearance, the capacity of the facility, and the location of dry ports. Alam (2016) identified factors such as issues with direct rail connection to the seaport that hinder efficient dry port operations in Pakistan and concluded that supportive policies are needed to overcome such issues and improve dry port performance.

4.4.2 Seaport performance

Improving railway infrastructure and establishing dry ports are important elements in a hinterland consolidation-distribution system, and the latter needs to be regulated and supported by policies and special institutions. Mirzabeiki et al. (2016) studied the effects of hinterland transportation between seaport and dry port with the inclusion of a collaborative tracking and tracing (CTT) system. The study concluded



that CTT positively affects the speed of operations, resource utilization, reliability, safety, and data quality. Fanti et al. (2015) addressed the optimization of lead time in both dry ports and seaport areas: the results of their modeling supported suggestions for reorganizing workflow in order to better utilize human resources. Qiu et al. (2015) looked into the problem of storage pricing at dry ports and its dependency on seaport pricing. Xie et al. (2017) focused on the problem of repositioning and coordinating empty containers at dry ports and seaports. By establishing dry ports, seaports could increase capacity without expanding their seaport terminals, as in the case—among many others—of Russian ports (Korovyakovsky and Panova 2011). In this way, seaports free up space for sensitive goods such as alcohol and tobacco, and gain a competitive advantage as a result of better access to hinterland areas (Rathnayake et al. 2013).

4.5 Network perspective

4.5.1 Dry port as an element of the transport network/supply chain

Once established, a dry port becomes part of a competitive transportation system that has numerous stakeholders with diverse strategies and interests. The growth stage of dry port development, referred to as “bidirectional development—outside-and-inside,” implies a joint effort towards dry port development by different actors engaged in hinterland transportation, and coincides with the active operation and business improvement phase of the dry port (Bask et al. 2014). Ng et al. (2013) present evidence from Brazil, where governmental institutions act either in support of or as an impediment to dry port development. That is, coordination between dry ports and seaports can be impeded due to lack of regulations, or, on the contrary, various difficulties in seaport operations might enhance dry port utilization. According to Wilmsmeier et al. (2011), the direction of dry port development as *inside-out* or *outside-in* is determined by existing policies for both public and private sectors. This conclusion is drawn from studying cases in Sweden, the USA, and Scotland (ibid). However, in the case of China, lack of coordination between institutions at different levels and the inability to interpret policies issued at higher levels in a beneficial manner hinder dry port development (Beresford et al. 2012). The problems are associated with the planning, operation, and regulation of hinterland transportation networks that are shared between authorities. Uncertainty, combined with new regulations, can slow the development of dry ports, i.e., they can deter long-term planning and investment (Ng and Tongzon 2010). On the other hand, supportive policies might accelerate a growing business, as illustrated by Jeevan et al. (2015a) in the case of container transportation through ports to the Malaysian hinterland. Strategies oriented towards better connectivity with foreign markets encourage seaports to develop connectivity with hinterland areas based on rail transport and, where possible, inland waterway transport (Notteboom and Yang 2017). Dry ports are elements of a hinterland transportation system, and their development depends on the state of other infrastructure.



4.5.2 Location issues and optimization

Awad-Núñez et al. (2016) argued that important location criteria include accessibility to a rail network, high-capacity roads, and seaports, and that dry port location decisions tend “to cater more to political preferences rather than technical criteria”. Ng and Cetin (2012) studied examples from India, emphasizing the importance of dry ports for a developing economy. Dry ports in the studied area deviated from optimal locations due to the influence of production facilities on location decisions, informal relationships between stakeholders, and policy restrictions. Flämig and Hesse (2011) also adopted a long-term perspective and investigated the positioning of dry ports. The authors considered the consequences that might arise with the development of dry ports as elements of port regionalization strategies, i.e., changes in transportation flow management, land use, governance, and planning. An interesting perspective was taken by Wang et al. (2018), who suggested the closure of existing dry ports with low throughput, together with the opening of new dry ports in more strategic locations, similar to the case of India, where oversupply of dry ports had led to economic losses. However, as Wang et al. (2018) noted, it might be practically difficult to eliminate inefficient infrastructure in light of the issue of “project image,” often tied to the image of local officials. Another body of publications focuses on finding optimal dry port locations and selecting better optimization methods. Ambrosino and Sciomachen (2014) investigated opportunities for establishing dry port networks in proximity to the port of Genoa, Italy, considering geographical location, volumes, mono- and multimodal approaches, and options for multiple or single mid-range dry ports. Feng et al. (2013) proposed implementation of dry ports in the Fujian region of China, dedicated to a seaport, or shared among different seaports—something that could facilitate transportation cost reduction. Most importantly, *success in facility placement* depends greatly on infrastructure development, and, as noted by Rathnayake et al. (2013), “any place” within a proper transportation network is suitable for a dry port.

5 Trends

The research field has grown in different directions, but only a few trends have been observed. First, the dry port concept has gained significant recognition in the transportation research field, as can be seen in Fig. 1, with the number of publications growing every year. Figure 3 is more specific, showing the trend or popularity of different thematic areas within the field of dry ports. Although the discussion on terminology and taxonomy periodically reappears in the reviewed publications, overall, publications with a strong focus on further defining the concept do not prevail. From Fig. 3 it is obvious that *network perspective* and performance impact are the most popular themes. Also, the two themes are closely related: a network perspective takes into consideration different forms of location optimization and dry port feasibility in different regions which, through their consequences, relate to dry port performance. In both themes, a quantitative approach to the problem prevails.



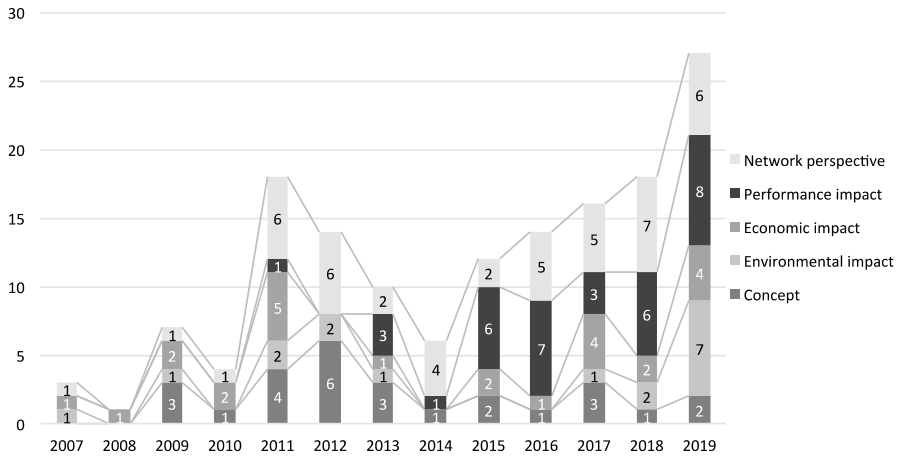


Fig. 3 Thematic areas covered by year

Aspects related to dry port functions, strategies, and operations might be constructed and conceptualized from already published case studies and new empirical evidence. Research has taken a perspective on dry ports which investigates the phenomenon as an element of a hinterland transportation system, often as an element of a seaport–dry port dyad (viewing it as a port regionalization concept). The environmental perspective is more in focus in recent studies on dry ports, but very few publications consider the broader perspective of dry port sustainability. Finally, a significant portion of research has focused on models for the optimal location of dry ports within the hinterland of a seaport. The knowledge generated has great potential to assist in the implementation of dry ports that are currently under consideration, to minimize the risk of insufficient cargo flows or excess infrastructure.

6 Future implications

Dry ports are a part of hinterland transportation systems, and their implementation can be initiated by different actors in the transport system. Such stakeholders have different objectives that could be fulfilled by developing such a facility. Benefits resulting from the implementation/availability of dry ports are summarized in Table 4. They mainly fall into the categories of sustainable development, i.e., social, economic, and environmental benefits. Table 4 shows numerous benefits extracted from the reviewed papers. Most of the benefits identified in this review are of an economic nature, although the concept has gained its popularity due to a range of environmental benefits identified.

The body of knowledge studied here covers thematic areas such as the debate on the concept itself, i.e., definition and taxonomy; environmental and economic impacts, usually through investigation of dry port applications in different regions; performance impact through dry port optimization and impact on seaport performance; and dry ports from a network perspective, as an element of a transportation



Table 4 Dry ports' utility-generating benefits for the stakeholders

Transport operators and shippers	
Optimized logistics (shorter time and lower costs)/lead time reduction	Jeevan et al. (2015a), Wang et al. (2016) and Panova (2011)
(Total) transportation/logistics cost minimization/decrease/reduction due to optimized design of hinterland transportation leg	Wilmsmeier et al. (2011), Roso et al. (2009), Lättilä et al. (2013), Zeng et al. (2013), Henttu and Hilmola (2011), Feng et al. (2013), Castagnetti (2012), Jeevan et al. (2015b), Henttu et al. (2011), Talley and Ng (2018) and Khaslavskaya and Roso (2019)
Obtaining added value through vertical integration	Rodrigue et al. (2010)
Improved rail–sea intermodal capacity	Roso (2008), Wang et al. (2016) and Roso (2013)
Increased seaport–hinterland accessibility	Roso (2008, 2013) and Jeevan et al. (2015a)
Improved hinterland network	Jeevan et al. (2015a)
Reduction in border transit delays	Roso and Lumsden (2010) and Do et al. (2011)
Lowered customs costs	Do et al. (2011) and Wang et al. (2016)
Reduction in external transportation costs	Henttu and Hilmola (2011)
Revenue source (private interest)	(Rodrigue et al. 2010)
Lower door-to-door freight rates/tariffs	Do et al. (2011) and Panova (2011)
Increased railway share	Roso (2008), Bask et al. (2014) and Panova and Hilmola (2015)
Good services for shippers and transport operators	Roso et al. (2009), Roso and Lumsden (2010) and Jeevan et al. (2015b)
Improved customer service	Roso and Lumsden (2010), Roso (2013) and Castagnetti (2012)
Reduced external costs associated with road congestion/associated accidents	Roso et al. (2009), Henttu and Hilmola (2011), Korovyakovsky and Panova (2011) and Othman et al. (2016)
Elimination of congestion and waiting time at a seaport	Roso (2007, 2009, 2013) and Roso and Lumsden (2010)
Cost reduction due to lower CO ₂ emissions/efficient use of energy	Lättilä et al. (2013) and Do et al. (2011)
Elimination of forwarding fees	Panova (2011) and Do et al. (2011)
Elimination of demurrage and late documentation fees	Do et al. (2011)
Improved quality of life	Roso et al. (2009)
Reduced risk of road accidents	Roso (2007, 2009) and Othman et al. (2016)
Reduced congestion in seaport cities	Korovyakovsky and Panova (2011) and Roso (2013)
Less traffic	Roso (2008, 2013) and Khaslavskaya and Roso (2019)
Reduced CO ₂ emissions along roads and seaports	Roso (2007, 2009), Korovyakovsky and Panova (2011), Hanaoka and Regmi (2011), Lättilä et al. (2013), Zeng et al. (2013), Dorostkar et al. (2016), Henttu and Hilmola (2011), Roso and Lumsden (2010), Regmi and Hanaoka (2012), Henttu et al. (2011), Do et al. (2011) and Khaslavskaya and Roso (2019)
Facilitating international trade	Hanaoka and Regmi (2011)



Table 4 (continued)

Increased reliability for shippers	Khaslavskaya and Roso (2019)
Seaports	
Secure and expand hinterland	Roso et al. (2019) and Khaslavskaya and Roso (2019)
Increase reliability of seaport	Jeevan et al. (2015a)
Reduced CO ₂ emissions at seaport area and local roads	Roso (2007), Korovyakovsky and Panova (2011), Hanaoka and Regmi (2011), Lättilä et al. (2013), Zeng et al. (2013), Dorostkar et al. (2016), Henttu and Hilmola (2011) and Roso and Lumsden (2010)
Increased seaport throughput/capacity	Roso et al. (2009), Jeevan et al. (2015a), Werikhe and Jin (2015), Talley and Ng (2018), Talley and Ng (2017), Fazi and Roodbergen (2018), Wilmsmeier et al. (2011), Rodrigue and Notteboom (2012)
Releasing expensive land at a seaport	Panova (2011) and Fazi and Roodbergen (2018)
Increased market share	Wilmsmeier et al. (2011)
Regions	
Obtaining added value through job creation (public interest)	Bask et al. (2014), Roso et al. (2009), Rodrigue et al. (2010), Jeevan et al. (2015a), Roso and Lumsden (2010), Do et al. (2011), Panova (2011), Khaslavskaya and Roso (2019) and Ng and Tongzon (2010)
Stimulation of national business	Jeevan et al. (2015a) and Ng and Tongzon (2010)
Regional development/creating new economic clusters	Bask et al. (2014), Jeevan et al. (2015a), Panova and Hilmola (2015), Panova (2011) and Ng and Tongzon (2010)
Smaller infrastructure investments	Roso et al. (2009), Bask et al. (2014) and Jeevan et al. (2015b)
Stimulation of international business	Jeevan et al. (2015a), Dorostkar et al. (2016) and Wang et al. (2016)

network by different location optimization studies. Studies addressing the most commonly represented thematic areas, i.e. a network perspective on dry ports or performance impacts, are based on quantitative approaches, but without taking into consideration, at least to a noticeable extent, the perspectives of the variety of actors involved. We therefore call for a more qualitative approach to the problem, which is in line with the recommendations of Gammelgaard (2004) in a study related to schools in logistics research: “[...]The actors’ approach is highly contextual and argues that it is impossible to make predictions based on external cause-effect-relations of social reality due to human beings’ intentionality. Therefore, an understanding of reality requires an investigation of intentions, primarily via qualitative studies.” (Gammelgaard 2004, p. 4).

Dry ports face challenges in their implementation and development phases. These relate to existing social, political, environmental, and financial regulations, or the lack thereof, and to technical and technological development, land and infrastructure



use, location and optimization issues, development and availability of infrastructure, stakeholder interests, and investments and a competitive business environment. At the same time, our research shows that dry ports could bring significant benefits to the stakeholders involved in hinterland transport operations by improving distribution systems, reducing direct and indirect logistics costs, stimulating regional development, and lowering the level of transportation emissions.

7 Conclusion

One hundred and two publications related to dry ports were extracted from the Scopus and Science Direct databases and reviewed in order to identify the main research themes, assess the current state of scientific knowledge, and outline research trends and future implications. The dry port concept has gained significant attention among researchers all around the world, mainly due to its potential to improve hinterland intermodal transportation, generate economic benefits, and reduce environmental impacts. In addition to research related to the development of the dry port concept itself, studies on environmental, economic, and performance impacts of dry ports, as well as dry ports from a network perspective, have also been carried out. A variety of methods have been used, but the research is represented predominantly by qualitative cases and quantitative modeling and optimization studies, with very few publications based on surveys of shippers or transport operators. This attention among researchers corresponds to the transport industry's interest in the phenomenon of dry ports that is represented in different forms around the world, fulfilling different purposes for various stakeholders. Consequently, the concept should be further studied by including multiple actors' perspectives. The fact that the number of peer-reviewed journal publications grew from two to over 100 in slightly over a decade shows a clear trend of interest in dry ports and indicates that this is an important emerging area of research.

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Appendix

Reviewed papers in chronological order with Scopus citations; citations marked with * are from ScienceDirect since the same were not available in Scopus

Authors	Year	Cited by	Title	Journal
Pham, H.T., Lee, H.	2019	1	Developing a Green Route Model for Dry Port Selection in Vietnam	Asian Journal of Shipping and Logistics
Wei, H., Dong, M.	2019	0	Import–export freight organization and optimization in the dry-port-based cross-border logistics network under the Belt and Road Initiative	Computers & Industrial Engineering
Laaziz, E.H., Sbihi, N.	2019	0	A service network design model for an inter-modal rail-road freight forwarder	International Journal of Logistics Systems and Management
Facchini, F., Digiesi, S., Mossa, G.	2019	2	Optimal dry port configuration for container terminals: A non-linear model for sustainable decision making	International Journal of Production Economics
Witte, P., Wiegmans, B., Ng, A.K.Y.	2019	5	A critical review on the evolution and development of inland port research	Journal of Transport Geography
Digiesi, S., Facchini, F., Mummolo, G.	2019	0	Dry port as a lean and green strategy in a container terminal hub: A mathematical programming model	Management and Production Engineering Review
Jeevan, J., Chen, S.-L., Cahoon, S.	2019	2	The impact of dry port operations on container seaports competitiveness	Maritime Policy and Management
Nguyen, L.C., Notteboom, T.	2019	2	The relations between dry port characteristics and regional port-hinterland settings: findings for a global sample of dry ports	Maritime Policy and Management
Hervás-Peralta, M., Poveda-Reyes, S., Molero, G.D., Santarremigia, F.E., Pastor-Ferrando, J.-P.	2019	3	Improving the performance of dry and maritime ports by increasing knowledge about the most relevant functionalities of the Terminal Operating System (TOS)	Sustainability



Authors	Year	Cited by	Title	Journal
Hui, F.K.P., Aye, L., Duffield, C.F.	2019	1	Engaging employees with good sustainability: Key performance indicators for dry ports	Sustainability
Khaslavskaya, A., Roso, V.	2019	4	Outcome-Driven Supply Chain Perspectives on Dry Ports	Sustainability
Li, W., Hilmola, O.-P., Panova, Y.	2019	0	Container sea ports and dry ports: Future CO2 emission reduction potential in China	Sustainability
Muravev, D., Rakhmangulov, A., Hu, H., Zhou, H.	2019	1	The introduction to system dynamics approach to operational efficiency and sustainability of dry port's main parameters	Sustainability
Roso, V., Russell, D., Rhoades, D.	2019	0	Diffusion of Innovation Assessment of Adoption of the Dry Port Concept	Transactions on Maritime Science
Qiu, X., Lee, C.-Y.	2019	4	Quantity discount pricing for rail transport in a dry port system	Transportation Research Part E: Logistics and Transportation Review
Tsao, Y.-C., Thanh, V.-V.	2019	3	A multi-objective mixed robust possibilistic flexible programming approach for sustainable seaport-dry port network design under an uncertain environment	Transportation Research Part E: Logistics and Transportation Review
Kramberger, T., Monios, J., Strubelj, G., Rupnik, B.	2018	5	Using dry ports for port co-opetition: The case of Adriatic ports	International Journal of Shipping and Transport Logistics
Tsao, Y.-C., Linh, V.T.	2018	3	Seaport- dry port network design considering multimodal transport and carbon emissions	Journal of Cleaner Production
Sholihah, S.A., Samadhi, T.M.A.A., Cakravastia, A., Nur Bahagia, S.	2018	1	Coordination model in hinterland chain of hub-and-spoke export trade logistics	Journal of Industrial Engineering and Management
Jeevan, J., Chen, S.-L., Cahoon, S.	2018	2	Determining the influential factors of dry port operations: worldwide experiences and empirical evidence from Malaysia	Maritime Economics & Logistics
Wang, C., Chen, Q., Huang, R.	2018	11	Locating dry ports on a network: a case study on Tianjin Port	Maritime Policy & Management
Black, J., Roso, V., Marušić, E., Brnjac, N.	2018	2	Issues in dry port location and implementation in metropolitan areas: The case of Sydney, Australia	Transactions on Maritime Science



Authors	Year	Cited by	Title	Journal
Chang, Z., Yang, D., Wan, Y., Han, T.	2018	2	Analysis on the features of Chinese dry ports: Ownership, customs service, rail service and regional competition	Transport Policy
Fazi, S., Roodbergen, K.J.	2018	8	Effects of demurrage and detention regimes on dry-port-based inland container transport	Transportation Research Part C: Emerging Technologies
Talley, W.K., Ng, M.	2018	6	Hinterland transport chains: A behavioral examination approach	Transportation Research Part E: Logistics and Transportation Review
Zhang, Q., Wang, W., Peng, Y., Zhang, J., Guo, Z.	2018	7	A game-theoretical model of port competition on intermodal network and pricing strategy	Transportation Research Part E: Logistics and Transportation Review
Qiu, X., Lam, J.S.L.	2018	2	The value of sharing inland transportation services in a dry port system	Transportation Science
Komchornrit, K.	2017	5	The Selection of Dry Port Location by a Hybrid CFA-MACBETH-PRO-METHEE Method: A Case Study of Southern Thailand	Asian Journal of Shipping and Logistics
Jeevan, J., Salleh, NHM., Loke, K.B., Saharuddin, A.H.	2017	1*	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
Nguyen, L.C., Notteboom, T.	2017	4	Public–private partnership model selection for dry port development: An application to Vietnam	World Review of Intermodal Transportation Research
Oey, E., Setiawan, V.	2017	2	Evaluating import cargo performance through Tanjung Priok sea port vs. Cikarang dry port-a case study in a FMCG company in Indonesia	International Journal of Logistics Systems and Management
Talley, W.K., Ng, M.	2017	6	Hinterland transport chains: Determinant effects on chain choice	International Journal of Production Economics
Santos, T.A., Guedes Soares, C.	2017	8	Development dynamics of the Portuguese range as a multi-port gateway system	Journal of Transport Geography



Authors	Year	Cited by	Title	Journal
Wei, H., Sheng, Z.	2017	4	Dry Ports-Seaports Sustainable Logistics Network Optimization: Considering the Environment Constraints and the Concession Cooperation Relationships	Polish Maritime Research
Notteboom, T., Yang, Z.	2017	31	Port governance in China since 2004: Institutional layering and the growing impact of broader policies	Research in Transportation Business & Management
Roso, V., Andersson, D.	2017	3	Dry Ports and Logistics Platforms	Encyclopedia of Maritime and Offshore Engineering
Chen, S.-L., Jeevan, J., Cahoon, S.	2016	2	Malaysian Container Seaport-Hinterland Connectivity: Status, Challenges and Strategies	Asian Journal of Shipping and Logistics
Othman, M.R., Jeevan, J., Rizal, S.	2016	2*	The Malaysian Intermodal Terminal System: The Implication on the Malaysian Maritime Cluster	International Journal of e-Navigation and Maritime Economy
Wanzala, W.G., Zhihong, J.	2016	5	Integration of the extended gateway concept in Supply Chain disruptions Management in East Africa-Conceptual paper	International Journal of Engineering Research in Africa
Mirzabeiki, V., Roso, V., Sjöholm, P.	2016	4	Collaborative tracking and tracing applied on dry Ports	International Journal of Logistics Systems and Management
Alam, J.	2016	0	Role of effective planning process in boosting dry port effectiveness: A case study of central Pakistan	International Journal of Supply Chain Management
Dorostkar, E., Shahbazi, S., Naeini, S.A.	2016	0	The effect of forming dry port in spatial and regional planning system in Yazd Province	Journal of Engineering and Applied Sciences
El Hassan, L.	2016	0	Modeling framework for intermodal dry port based hinterland logistics system	Journal of Theoretical and Applied Information Technology
Muravev, D., Rakhmangulov, A.	2016	3	Environmental Factors' Consideration at Industrial Transportation Organization in the «seaport-Dry port» System	Open Engineering
Rožić, T., Rogić, K., Bajor, I.	2016	4	Research trends of inland terminals: A literature review	Promet - Traffic



Authors	Year	Cited by	Title	Journal
Nguyen, L.C., Notteboom, T.	2016	25	Multi-Criteria Approach to Dry Port Location in Developing Economies with Application to Vietnam	The Asian Journal of Shipping and Logistics
Wang, G.W.Y., Zeng, Q., Li, K., Yang, J.	2016	19	Port connectivity in a logistic network: The case of Bohai Bay, China	Transportation Research Part E: Logistics and Transportation Review
Awad-Núñez, S., Soler-Flores, F., González-Cancelas, N., Camarero-Orive, A.	2016	1	How should the Sustainability of the Location of Dry Ports be Measured?	Transportation Research Procedia, Transport Research Arena
Jeevan, J., Ghaderi, H., Bandara, Y.M., Saharudin, A.H., Othman, M.R.	2015	2*	The implications of the growth of port throughput on the port capacity: the case of Malaysian major container seaports	International Journal of e-Navigation and Maritime Economy
Li, Y., Dong, Q., Sun, S.	2015	10	Dry port development in china: Current status and future strategic directions	Journal of Coastal Research
Fanti, M.P., Iacobellis, G., Ukovich, W., Boschian, V., Georgoulas, G., Stylios, C.	2015	16	A simulation based Decision Support System for logistics management	Journal of Computational Science
Clott, C., Hartman, B.C., Ogard, E., Gatto, A.	2015	8	Container repositioning and agricultural commodities: Shipping soybeans by container from US hinterland to overseas markets	Research in Transportation Business & Management
Panova, Y., Hilmola, O.-P.	2015	9	Justification and evaluation of dry port investments in Russia	Research in Transportation Economics, Austerity and Sustainable Transportation
Bentaleb, F., Mabrouki, C., Semma, A.	2015	7	A Multi-Criteria Approach for Risk Assessment of Dry Port-Seaport System	Supply Chain Forum
Jeevan, Jagan, Chen, S., Lee, E.	2015	14	The Challenges of Malaysian Dry Ports Development	The Asian Journal of Shipping and Logistics
Chang, Z., Notteboom, T., Lu, J.	2015	10	A two-phase model for dry port location with an application to the port of Dalian in China	Transportation Planning and Technology
Crainic, T.G., Dell'Olmo, P., Ricciardi, N., Sgalambro, A.	2015	33	Modeling dry-port-based freight distribution planning	Transportation Research Part C: Emerging Technologies, Engineering and Applied Sciences Optimization
Qiu, X., Lam, J.S.L., Huang, G.Q.	2015	14	A bilevel storage pricing model for outbound containers in a dry port system	Transportation Research Part E: Logistics and Transportation Review



Authors	Year	Cited by	Title	Journal
Li, J., Jiang, B.	2014	4*	Cooperation Performance Evaluation between Seaport and Dry Port; Case of Qingdao Port and Xi'an Port	International Journal of e-Navigation and Maritime Economy
Bask, A., Roso, V., Andersson, D., Hämäläinen, E.	2014	29	Development of seaport-dry port dyads: Two cases from Northern Europe	Journal of Transport Geography
Ambrosino, D., Sciomachen, A.	2014	13*	Location of Mid-range Dry Ports in Multimodal Logistic Networks	Procedia - Social and Behavioral Sciences
Awad-Núñez, S., González-Cancelas, N., Camarero-Orive, A.	2014	4*	Application of a Model based on the Use of DELPHI Methodology and Multicriteria Analysis for the Assessment of the Quality of the Spanish Dry Ports Location	Procedia - Social and Behavioral Sciences
Feng, X., Zhang, Y., Li, Y., Wang, W.	2013	9	A Location-Allocation Model for Seaport-Dry Port System Optimization	Discrete Dynamics in Nature and Society
Rathnayake, J., Jing, L., Wijeratne, A.W.	2013	2	Dry ports: a lacuna in Sri Lanka	International Journal of Process Management and Benchmarking
Onyemechi, C.	2013	0	Logistics Centres Assessed as a Port City Decongesting Strategy: Case Study of a Nigerian Port City	Journal of Maritime Research
Ng, A.K.Y., Padilha, F., Pallis, A.A.	2013	40	Institutions, bureaucratic and logistical roles of dry ports: the Brazilian experiences	Journal of Transport Geography
Onyemechi, C.	2013	0	Port efficiency modelling in the post concessioning era: The role of logistics drivers, agile ports and other perspectives	Pomorstvo
Zeng, Q., Maloni, M.J., Paul, J.A., Yang, Z.	2013	11	Dry port development in China: Motivations, challenges, and opportunities	Transportation Journal
Lättilä, L., Henttu, V., Hilmola, O.-P.	2013	55	Hinterland operations of sea ports do matter: Dry port usage effects on transportation costs and CO2 emissions	Transportation Research Part E: Logistics and Transportation Review
Panova, Y., Korovyakovsky, E.	2013	3	Perspective reserves of Russian seaport container terminals	World Review of Intermodal Transportation Research



Authors	Year	Cited by	Title	Journal
Roso, V.	2013	24	Sustainable intermodal transport via dry ports—importance of directional development	World Review of Intermodal Transportation Research
Beresford, A., Pettit, S., Xu, Q., Williams, S.	2012	55	A study of dry port development in China	Maritime Economics & Logistics
Padilha, F., Ng, A.K.	2012	31	The spatial evolution of dry ports in developing economies: The Brazilian experience	Maritime Economics & Logistics
Haralambides, H., Gujar, G.	2012	34	On balancing supply chain efficiency and environmental impacts: An eco-DEA model applied to the dry port sector of India	Maritime Economics and Logistics
Veenstra, A., Zuidwijk, R., Van Asperen, E.	2012	83	The extended gate concept for container terminals: Expanding the notion of dry ports	Maritime Economics and Logistics
Monios, J., Wilmsmeier, G.	2012	53	Port-centric logistics, dry ports and offshore logistics hubs: strategies to overcome double peripherality?	Maritime Policy and Management
Ng, A.K.Y., Cetin, I.B.	2012	36	Locational Characteristics of Dry Ports in Developing Economies: Some Lessons from Northern India	Regional Studies
Regmi, M.B., Hanaoka, S.	2012	21	Assessment of intermodal transport corridors: Cases from North-East and Central Asia	Research in Transportation Business & Management
Rodrigue, J.-P., Notteboom, T.	2012	43	Dry ports in European and North American intermodal rail systems: Two of a kind?	Research in Transportation Business and Management
Ambrosino, D., Sciomachen, A.	2012	3	How to reduce the impact of container flows generated by a maritime terminal on urban transport	WIT Transactions on Ecology and the Environment
Hanaoka, S., Regmi, M.B.	2011	50	Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective	IATSS Research
Ka, B.	2011	42	Application of fuzzy AHP and ELECTRE to China dry port location selection	Asian Journal of Shipping and Logistics



Authors	Year	Cited by	Title	Journal
Panova, Y.	2011	9	Potential of connecting Eurasia through Trans-Siberian Railway	International Journal of Shipping and Transport Logistics
Wilmsmeier, G., Monios, J., Lambert, B.	2011	73	The directional development of intermodal freight corridors in relation to inland terminals	Journal of Transport Geography
Dadvar, E., Ganji, S.R.S., Tanzifi, M.	2011	4	Feasibility of establishment of "Dry Ports" in the developing countries- the case of Iran	Journal of Transportation Security
Do, N.-H., Nam, K.-C., Le, Q.-L.N.	2011	12	A consideration for developing a dry port system in Indochina area	Maritime Policy and Management
Haralambides, H., Gujar, G.	2011	20	The Indian dry ports sector, pricing policies and opportunities for public-private partnerships	Research in Transportation Economics
Korovyakovskiy, E., Panova, Y.	2011	16	Dynamics of Russian dry ports	Research in Transportation Economics
Flämig, H., Hesse, M.	2011	28	Placing dryports. Port regionalization as a planning challenge – The case of Hamburg, Germany, and the Süderelbe	Research in Transportation Economics
Henttu, V., Hilmola, O.-P.	2011	28	Financial and environmental impacts of hypothetical Finnish dry port structure	Research in Transportation Economics
Monios, J.	2011	40	The role of inland terminal development in the hinterland access strategies of Spanish ports	Research in Transportation Economics
Henttu, V., Lättilä, L., Hilmola, O.-P.	2011	7	Optimization of relative transport costs of a hypothetical dry port structure	Transport and Telecommunication
Rodrigue, J.-P., Debie, J., Fremont, A., Gouvernal, E.	2010	125	Functions and actors of inland ports: European and North American dynamics	Journal of Transport Geography, Special Issue
Ng, A.K., Tongzon, J.L.	2010	22	The transportation sector of India's economy: dry ports as catalysts for regional development	Eurasian Geography and Economics
Roso, V., Lumsden, K.	2010	63	A review of dry ports	Maritime Economics & Logistics
Ng, K.Y.A., Gujar, G.C.	2009	63	The spatial characteristics of inland transport hubs: evidences from Southern India	Journal of Transport Geography



Authors	Year	Cited by	Title	Journal
Roso, V., Woxenius, J., Lumsden, K.	2009	221	The dry port concept: connecting container seaports with the hinterland	Journal of Transport Geography
Ng, Adolf K. Y., Gujar, G. C.	2009	47	Government policies, efficiency and competitiveness: The case of dry ports in India	Transport Policy
Roso, V.	2009	15	The emergence and significance of dry ports: The case of the Port of Goteborg	World Review of Intermodal Transportation Research
Roso, V.	2008	62	Factors influencing implementation of a dry port	International Journal of Physical Distribution & Logistics Management
Jaržemskis, A., Vasiliauskas, A. V.	2007	51	Research on dry port concept as intermodal node	Transport
Roso, V.	2007	81	Evaluation of the dry port concept from an environmental perspective: A note	Transportation Research Part D: Transport and Environment

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