Greening Corridors

On the Dry port to Dry port-concept

Gaining a better understanding of the added value

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Abstract

This research is part of a project which has been initiated by the Indonesian province of West Java and the Dutch province of Gelderland. The overall aim of the project is to create a seamless multi-modal supply chain between the two provinces, whereby increasing the sustainability and (cost-)efficiency of logistics activities. It is expected that this can be achieved by means of a Dry port to Dry port-concept (DP2DP-concept). The study presented in this paper focuses on the (potential) added value of a DP2DP-concept. This contribution first provides insight into what a dry port to dry port (DP2DP) concept entails. In addition, it also provides an overview of the key logistics performance indicators in the context of this concept. Finally, the added value of a DP2DP concept is elaborated on for each of the identified performance indicators.

Introduction

The rapid growth in freight volumes through seaports in recent decades has led, among other things, to an increase in traffic congestion, lack of space for seaport operations, and environmental pollution (Awad-Núñez et al., 2015). Since seaports are in direct connection with the hinterland, the surrounding area also experiences the negative environmental effects of an increase in logistics flows (Khaslavskaya & Roso, 2019). The dry port (DP) concept is advocated as a prominent sustainable solution to the problems outlined above (Tadić et al., 2020).

And although being used interchangeably with terminologies like inland terminals, freight village, Inland Container Depot (ICD), inland port and other notions, a dry port has its own distinguished characteristics in view of establishing a closer integration between seaports and hinterlands (Nguyen & Notteboom, 2019). A well-known definition of a dry port is given by Leveque & Roso (2002). They define a dry port as: *"An inland terminal directly connected to seaport(s) with high-capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport"*. Hence, this definition assumes that a dry port provides the same services and service-level as a seaport. In practice, being connected to a seaport by means of a high-capacity transportation mode often implies a railway connection and less frequent a barge/inland waterway connection (Khaslavskaya & Roso, 2020). When it comes to the interconnection between a sea- and dry port, it is important to mention that in practice a seaport often consists of independent operating terminals by which shipments enter or leave the seaport. As such, on a more detailed level, a dry port is connected to one or more terminals.

In addition to the services provided by a conventional inland terminal, a full-service dry port offers services like storage, consolidation, depot-storage of empty containers, maintenance and repair of containers and customs clearance. According to Van Klink (2001), a full-service dry port should be considered as an extended gate of a seaport, through which transport flows can be better controlled and adjusted to match conditions. Following the same line of reasoning Veenstra, Zuidwijk & Van Asperen (2012) state that instead of waiting for containers to be picked up by truck, rail or barge, seaport terminals should be able to push blocks of containers into the hinterland, to alleviate congestion. Based on the definition of Leveque & Roso (2002) and Veenstra, Zuidwijk & Van Asperen (2012), we define a full-service dry port (which operates as an extended gate) as a dry port *"where the seaport terminal can choose to control the flow of containers to and from the inland terminal"*. Veenstra, Zuidwijk & Van Asperen (2012) argue that the dry port concept is based on the idea that not all industrial and economic activities take place in the direct area of seaports, and that an efficient inter- or multimodal infrastructure and inland nodes can help accommodate trade growth and can direct regional development inland. In recent years, dry ports have gained growing attention in both academia and business practice (see e.g., Varese, Marigo & Lombardi, 2020; Rožić, Rogić & Bajor, 2016; Lamii et al., 2020; Miraj, 2021).

Most of the emphasis in existing literature on dry ports has been on one end of the supply chain. In this study, the focus lies on gaining more insight into the (potential) added value of having full-service dry ports at both ends of a supply chain. More specifically, in this study, we provide insight into the added value of a "dry port to dry port" supply chain structure (from now on referred to as DP2DP-concept). This will be done by, first, providing an overview of the key performance dimensions. Next, for each performance dimension, we will elaborate on the added value of a DP2DP-concept. To the best of our knowledge, this is the first study which examines the dry port concept from an end-to-end perspective.

The remainder of this paper is structured as follows. Section 2 illustrates the setting and discusses the research methods adopted in this study. In Section 3, the logistics performance dimensions are presented. Next, section 4 discusses the added value of a DP2DP-concept. Finally, in Section 5, conclusions are drawn and implications for practice and future research directions are discussed.

Context & Methodology

This research is part of a three-year project (2019-2022), which was initiated by the Indonesian province of West Java and the Dutch province of Gelderland. The overall aim of the project was to create a seamless multi-modal supply chain between the two provinces, whereby increasing the sustainability and (cost-)efficiency of logistics activities. It was expected that this could be achieved by means of a DP2DP-concept.

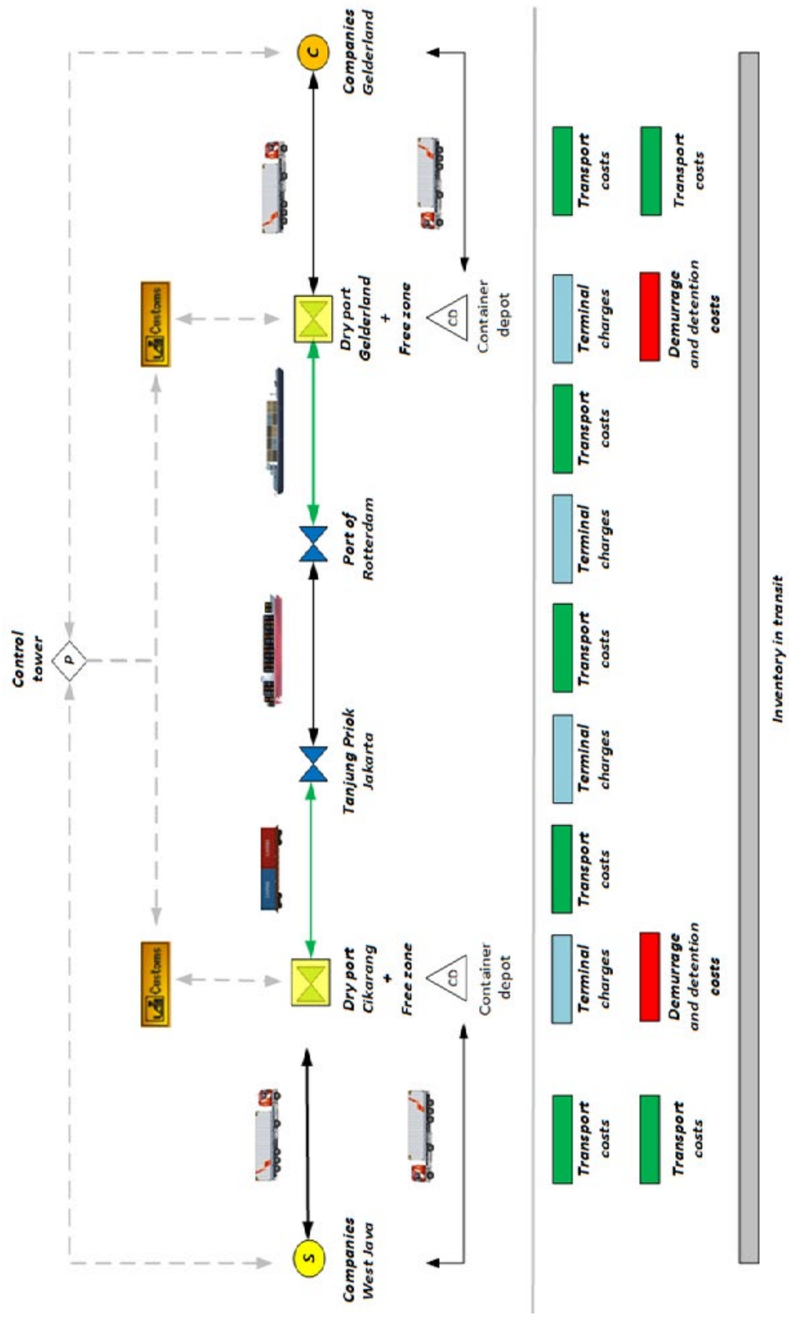

Figure 1 shows a visual representation of the DP2DP-concept between Gelderland and West Java

The basic idea behind a DP2DP-concept is that focusing on one end of the supply chain will not lead to optimal benefits. Hence, an end-to-end perspective (such as a DP2DP-concept) is necessary to create a green, adaptive and efficient supply chain. A DP2DP-concept includes a dry port in the country of departure as well as in the country of arrival. Both dry ports have a connection with the seaport by rail or barge. The shipments are sent from dry port to dry port using a Multimodal Transport Bill of Lading. To enable this, a dry port has a seaport code. Customs clearance is done in the dry ports instead of in the seaports. In addition, each of the involved dry ports has a depot of empty containers. The supply chain operations are monitored and orchestrated by means of a Supply Chain Control Tower (SCCT). In this context, a SCCT can be described as a centralized solution that provides monitoring capabilities to manage end-to-end supply chain operations efficiently. It enables supply chain parties to track, understand and resolve critical issues in real-time. The study presented in this paper focuses on the (potential) added value of a DP2DP-concept.

With this setting and overall objective in mind, the following research approach has been chosen. First, in order to gauge the added value of a DP2DP-concept in relation to an organization's long-term and short-term objectives, logistics performance dimensions have been identified. This has been done by applying a two-step approach (see also Section 3):

1. Defining an initial set of logistics performance dimensions using existing scientific literature.
2. Validation and further elaboration of the initial set of performance dimensions using interviews with supply chain stakeholders.

Next, for each performance dimension the added value of a DP2DP-concept will be elaborated on using insights gained from multiple case studies and existing literature.

Performance dimensions

The first step of our two-step approach, as presented in Section 2, consists of defining an initial set of logistics performance dimensions. For this first step existing literature has been consulted, of which the results are presented in the following subsection. The second step (i.e., the validation of the initial set of performance dimensions) is discussed in the subsequent subsection.

Initial set of performance dimensions

According to Beamon (1999), measuring the overall performance of a supply chain requires a set of measures which captures all pertinent dimensions of performance. These dimensions (and corresponding KPIs) are often interrelated. Hence, maximizing one dimension of performance can in some cases only be achieved at the detriment of performance in another dimension. Consequently, by limiting the scope of the dimensions there is a risk of ignoring important performance trade-offs. Beamon (1999) defines the following three (interrelated) performance dimensions: 1) Customer service, 2) Resource efficiency and 3) Flexibility. Customer service can be regarded as the output of a logistics system with customer satisfaction as overall objective (Beamon, 1999; Leuschner, Charvet & Rogers, 2013). In the context of this study, it is strongly related to the ability of a supply chain to deliver the right product in the right amount at the right place at the right time for the right customer in the right condition at the right price (i.e., the 7Rs) (Shapiro & Heskett, 1985). However, logistics entails more than meeting the customer wants and needs alone. Resource efficiency should also be taken into account, which refers to the ability of a supply chain to achieve the desired output with as little possible "waste" of resources (i.e., time, money, capacity and raw materials) (see e.g., Gleason & Barnum, 1982). As such, in this context, resource efficiency can be defined as the amount of resources consumed in order to generate the required customer benefit. According to Sfez et al. (2017), from a measuring perspective, the most challenging step is quantifying the resource consumption as a *"wide range of methods to quantify resource consumption exist and are being used"*. Flexibility is also regarded by Beamon (1999) as an important logistics performance dimension, which refers to the ability of a supply chain to adequately adapt or respond to uncertain and unknown future business conditions. Flexibility is also recognized by e.g., Lee & Billington (1993); Duclos, Vokurka & Lummus (2003); Vickery, Calantone & Dröge (1999) as being a crucial logistics performance dimension.

To further deepen and refine the aforementioned dimensions we used the Supply Chain Operations Reference (SCOR)-model, which is a widely employed model for supply chain performance assessment. The model recognizes five dimensions: 1) Reliability, 2) Responsiveness, 3) Agility, 4) Costs and 5) Efficiency (APICS, 2023). Reliability is defined by the SCOR-model as: *"The ability to perform tasks as expected".* One could say that reliability is about delivering the right product, in the right amount at the right time for the right customer, in the right condition. As such, for the purpose of this study, the terms reliability and customer service are interchangeable. According to the SCOR-model, responsiveness refers to *"the speed at which a supply chain provides products to the customer".* Hence, it can be regarded as the shipping lead time which is the time it takes to ship the goods from the supplier to the customer.

The dimension agility requires some further elaboration along with the concept's flexibility, robustness and resilience which all relate to the ability of coping adequately with supply chain uncertainties (i.e., adaptability). Regarding these concepts, Husdal (2010) states the following: "*Flexibility or agility is the inherent capability to modify a current direction to accommodate and successfully adapt to changes in the environment, whereas robustness refers to the ability to endure such changes without adapting. Resilience is the ability to survive despite withstanding a severe and enduring impact. Resilience, in essence, is the ability to* *survive disruptive changes despite severe impact".* Following this line of reasoning, we define robustness as the ability of a supply chain to cope with uncertainties without adapting its initial stable configuration. However, unlike Husdal (2010), we would like to distinguish between flexibility and agility. According to Abdelilah, El Korchi & Balambo (2018), flexibility can be regarded as an intrinsic characteristic that enables a system to adjust to change within pre-established settings. In line with this view, we define flexibility as the extent to which a supply chain is able to make and implement changes in its day-to-day planning to accommodate regular fluctuations in demand and supply. Agility, on the other hand, we define as the ability to rapidly and dynamically reconfigure a supply chain system when faced with unforeseen and unexpected external circumstances (based on Bernardes & Hanna, 2009; Seethamraju & Seethamraju, 2009). Finally, in line with Husdal, we define resilience as the ability of a supply chain system to adequately cope with large-scale disruptions. See Figure 1 for an overview of how the concepts robustness, flexibility, agility, and resilience interrelate.

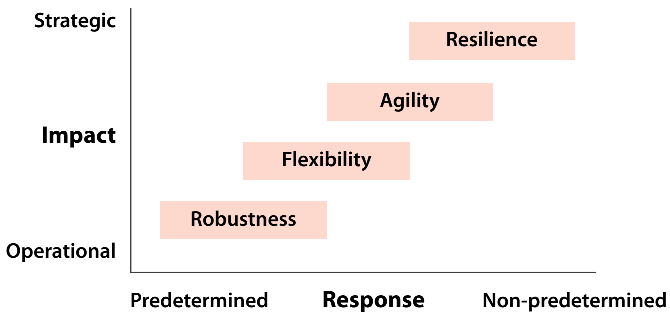

Figure 2 Types of adaptability

Within the SCOR-model, resource efficiency is divided into costs and efficiency. We have chosen to adopt this specification. Costs can be defined as the value of money related to operating the supply chain processes. This includes labor costs, material costs, and management and transportation costs. In general, efficiency can be defined as the extent to which time, effort, or cost is well-used for the intended task or purpose (see e.g., Negi & Anand, 2014).

Finally, the role of sustainability dimensions in the value creation process has aroused much interest in academia over the past two decades. Also supply chain parties are becoming more and more aware of the importance to improve their environmental performance in addition to improving their economic performance. As such, we chose to extend the initial set of performance dimension with environmental sustainability, using the following definition: *"The ability to provide products through a supply chain that ensures controlled and minimal resource impact, both today and in the future"* (Melnyk, Spekman, & Sandor, 2010). An overview of the initial set of performance dimensions can be found in Table 1.

Table 1 Initial set of logistics performance dimensions

Performance dimension	Definition
Reliability	Performing tasks as expected, i.e., perfect order fulfillment
Costs	The value of money related to operating the supply chain process
Efficiency	Achieving the desired output with as little possible "waste" of resources (financial, human, technological or physical)
Adaptability	The ability of coping adequately with supply chain uncertainties
Delivery speed	The time it takes to ship the goods from the supplier to the customer
Environmental Sustainability	The ability to provide products through a supply chain that ensures controlled and minimal resource impact, both today and in the future

Validation by means of interviews

Next, the initial set of performance dimensions (see Table 1) has been validated and further refined through the use of interviews with in total 17 supply chain stakeholders. The conducted interviews were semi-structured. If required, the questions were adapted to the specific stakeholder. The inclusion criteria for the sample selection of supply chain professionals were set as follows: A manager or director and (1) working at a dry port, or (2) working at an im- or export company familiar with dry ports, or (3) involved in the logistics processes surrounding truck, rail and barge and familiar with dry ports, or (4) directly involved in the handling of goods at a seaport, or (5) a supply chain consultant with expertise regarding dry- and/ or seaports. An overview of the background of the interviewees is shown in Table 2.

Table 2 Overview interviewees

Interviewee #	Type of company	Position of interviewee
1	Fashion company	Logistics Manager
2	Food company	Transport Manager
3	Furniture company	Director
4	Importing trade company	Logistics Manager
5	Logistics Service Provider	Account Manager
6	Logistics Service Provider	Manager Import
7	Fashion company	Logistics Manager
8	Importer and distributor food	Supply Chain Manager
9	Dry port	Account Manager
10	Dry port	General Manager
11	Dry port	General Manager
12	Dry port	General Manager
13	Forwarder	Account Manager
14	Logistics Service Provider	Import Manager
15	Province of The Netherlands	Policy Maker
16	Furniture company	Director
17	Shipping company	Account Manager

In general, the results of the interviews show that the initially identified performance dimensions are considered important by a significant proportion of interviewees (See Table 3).

Table 3 Validation initial set of logistics performance measures

Performance dimension	Interviewee #																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Reliability		X					X		X	X	X					X	X
Costs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Efficiency						X				X							
Adaptability	X			X		X		X	X		X	X					
Delivery speed	X	X	X				X	X								X	X
Environmental sustainability		X			X	X			X	X	X	X	X	X	X		

The only exception to this is "efficiency", which was mentioned as an important performance dimension by only 2 of the 17 interviews. In the remainder of this section, the initial set of performance dimension (and corresponding definitions) will be elaborated on and further refined. The most salient statements of the interviewees were included in the analysis presented.

All of the interviewees mentioned costs as an important logistics performance dimension. Multiple interviewees indicated that the use of a dry port leads to a reduction in costs. Regarding costs, interviewee 2 stated: *"For us it's crucial to maintain low costs for transporting containers from our factory to the seaport. We believe that using the dry port helped to avoid demurrage and detention costs. Empty containers can be picked up and returned to the container depot at the dry port instead of the sea terminal"*. According to interviewee 9: *"The cost benefits do not only relate to transport costs. The most prominent cost benefits stem from the fact that a customer can use a dry port as a depot for containers which cannot be stored in their own warehouse immediately. When warehouses were full at the start of COVID-crisis, many customers took advantage of this buffer function. This is the most important reason for import and export companies to use a dry port, because a dry port unburdens them. For an import or export company, it is easier to scale up or down the number of containers you receive or send"*. As such, using a dry port also increases the supply chain adaptability. This adaptability advantage was mentioned by multiple stakeholders. Interviewee 4, who works for a company with a high seasonality factor, indicated that they use the dry port as "their floating warehouse". During the pre-season period the company is not able to handle and store the large number of containers in their own warehouse. Storing the containers at the seaport would be too expensive, whereas the dry port allows them to keep their containers 30 days for free. During the pre-season period, they store around 200-300 containers (on average) at the dry port waiting for release. The company of interviewee 2 aims to develop reliable, efficient, and flexible supply chains for their main export markets. The choice to use a dry port is conscious one, building on experience and anticipation on future changes. On short notice they think it's more convenient and faster to pick up the empty containers and transport the full containers back to at a nearby dry port. Besides the lower costs, it increases their flexibility. The buffer function of the dry port enables that empty containers can be called off exactly when needed, and that full containers can be shipped to the dry port right away. Local communication helps to fine tune the daily planning. Anticipating on the future shortage of truck drivers, the increasing pressure to be more environmentally friendly and volatile supply chains they strongly believe in the added value of dry ports. Small importers and exporters usually choose for road, because they depend on just a few containers a month. In addition, they cannot afford any lead time which is associated with multi-modal transport. Lead time is also mentioned by other interviewees as an important performance dimension. An extra day of lead time can be a barrier for using a dry port. Other interviewees point out that when using a dry port as a buffer, the containers can be delivered exactly when needed. Hence, a dry port can provide support in their realization of a just-in-time delivery system.

Table 4 presents the final set of logistics performance dimensions. In order to minimize duplication or redundancy, inter-correlations between the performance dimensions have been carefully considered. For this reason, compared to the initial set, the dimension "efficiency" has been left out.

Table 4 Final set of logistics performance measures

Performance dimension	Definition
Reliability	Performing tasks as expected, i.e., perfect order fulfillment
Costs	The value of money related to operating the supply chain process
Adaptability	The ability of coping adequately with supply chain uncertainties
Delivery speed	The time it takes to ship the goods from the supplier to the custome
Environmental Sustainability	The ability to provide products through a supply chain that ensures controlled and minimal resource impact, both today and in the future

The added value of a DP2DP-concept

Using the outcome of section 3 (see table 4) as a starting point, this section will look more closely at the added value of a DP2DP concept. For each performance dimension, the added value of a DP2DP concept will be elaborated on using insights gained from multiple case studies and existing literature.

Reliability

A dry port constitutes an additional link in the supply chain, and in theory will add time, costs and risks. However, a mature dry port has not only a seamless and reliable connection with seaport terminals, but also an efficient multi-model connection with the hinterland. As such, a DP2DP-concept provides a multi-modal connectivity with the hinterland, combined with a seamless seaport connection on both ends of the supply chain. This connectivity advantage, together with a Supply Chain Control tower approach, creates a supply chain infrastructure which allows early detection of disruptions or bottlenecks and mitigation of delays. Consequently, a DP2DP-concept enhances the ability to deliver the right product at the right place at the right time. That the use of dry ports has a positive impact on reliability is also explicitly mentioned in the study of Jeevan, Chen & Cahoon (2019).

Costs

Based on our case studies, we can conclude that a DP2DP-concept can be advantageous in terms of transportation costs, customs costs and demurrage and detention costs.

If the shipper and receiver are within the service area of a dry port, the distance from to the dry port is shorter than to the seaport. Under these conditions, a DP2DP concept results in a reduction in the number of transport kilometres from and to the seaport (of both full and empty containers). In addition, the increase in the use of rail or inland water transport (instead of transport by road) should, in most cases, also lead to lower transportation costs. Furthermore, when we look at customs costs, the rates for the customs formalities are lower in a dry port than at a seaport terminal. The actual savings depend on the volume of containers and negotiations with logistics service providers. Finally, a DP2DP concept can also be beneficial in terms of demurrage and detention costs. Within a well-functioning DP2DP-concept the dry ports (at both ends of the supply chain) will coordinate the transport of the containers from and to the seaport. Export containers will stay at the dry port, until the exact date of arrival of the sea vessel at the seaport terminal is known. The dry port will collect an import container as quickly out of the seaport terminal. This means that the containers will not stay in the seaport longer than needed. This will lead to lower costs, as rates for demurrage are lower in dry ports.

During one of our case studies, for three months, we closely and carefully monitored the container shipments of a Dutch company between Gelderland and West Java. Using the supply chain visibility platform Project44 and with some transport information of OOCL, we were able to calculate the costs, lead-times and emissions for each of the shipments. Thanks to this study, it became clear that using a dry port led to a reduction in demurrage costs. When looking at the total costs from an end-to-end perspective, the results of this case study showed that: For the Dutch side, applying a DP2DP concept resulted in direct cost benefits. However, on the West Java side, it did not result in direct cost benefits. The main reason was that transport by road, compared to transport by rail, was significantly cheaper. However, the case study also shows that (even for the West Java side), when temporary storage is desirable, working through the dry port brings direct cost benefits.

Our findings are in line with Roso and Lumsden (2010) and Jeevan and Roso (2019). These studies argue that the significant growth in vessel size has forced gateway ports to have a higher degree of synchronization with their hinterlands through specialized high-capacity transport corridors serviced by rail or barges, often including dry ports. This is necessary to transfer huge volumes of containers from vessel to hinterland and vice versa in a very short time to reduce demurrage. Hence, the inland transportation system must be well connected to and from seaports to shorten the dwelling time of containers.

Finally, we would like to mention that during times of shortages of containers, the shipping companies tend to minimize the free time of the containers. The fact that within the DP2DP-concept the empty container depot is closer to the receiver, provides more time to return the container for the receiving company. This results in savings in terms of detention costs.

Adaptability

A DP2DP-concept is highly adaptable to supply chain disruptions, largely due to its Supply Chain Control Tower (SCCT) function and buffering capabilities. The SCCT-function reduces uncertainty, where uncertainty can be defined as the difference between the information needed to perform a task and the information available to the organization (Galbraith,1973). From an adaptability perspective, reducing uncertainty helps increasing the responsiveness. In addition, with respect to adaptability, buffering capabilities also plays a crucial role. Temporary storage of large incoming or outgoing quantities of containers will enable companies to arrange the capacity of the workforce in their warehouses and to minimize the required storage capacity and working space at their premises.

Contemporary supply chains are more subject to uncertainties than before (Russell, Ruamsook & Roso, 2020; Vlajic, Van der Vorst & Djurdjevic, 2019). In recent years, there have been many examples of supply chain disruptions, with the COVID-19-pandamic as prominent example. During the COVID-19 pandemic sea freight schedules were in disorder, ships were delayed, sea containers were scarce, and sea terminals were congested. Export and import companies paid the price through exploded transport costs, long lead times, and increased costs for demurrage and detention. A side-effect was that delayed shipments regularly arrived at a seaport together with shipments that were shipped at a later date, confronting the import companies with sudden, unforeseen and sometimes unmanageable peak loads in their inbound operations. When it comes to manageability, storing containers at a dry port can substantially help reduce undesirable peak loads. In this context it is important to mention that storage costs at a dry port are lower than at a seaport terminal, in some cases even for free. Another advantage is, that the containers are stored nearby the import company, and can be called-off at short notice. In this context, Khaslavskaya and Roso (2019) state that: "*The proximity of a dry port to a customer's facilities allows for more accurate planning of deliveries*".

The case studies also show that dry ports play an important role when it comes to providing or collecting empty containers. As part of their value-added services, unlike remote seaports, they can offer their local customers practical and flexible "buffer" solutions. In this way, exporters can better streamline their "container planning" and importers can swiftly and efficiently return the container to dry port after unloading.

Delivery speed

Despite the fact that transportation by rail and inland waterways is generally slower than transportation by road, a DP2DP-concept potentially provides several benefits in terms of delivery speed. First, from a somewhat broad perspective, dry ports have a positive effect on the reduction of congestion at the seaport terminals and the surrounding urban area. This main reason for this is that the use of intermodal transport reduces the number of truck movements (e.g., Roso, Woxenius & Lumsden, 2009). This benefit is also evident from a real-life DPDP-example: The DP2DP-connection between Cikarang Dry Port (CKD) in Indonesia and Lat Krabang Inland Container Depot (LICD) in Thailand illustrates that it can support lead time reduction. By means of the DP2DP-concept, CKD and LICD were able to decrease the existing total average lead-time from 7 days to 6 days.

Environmental sustainability

Within a DP2DP-concept transport by barge or rail is used between the seaport and the dry port. Depending on the type of vehicles used (i.e., electric vs fossil fuel) and the loading density of barge and rail, a substantial saving in the output of CO_2 (and other emissions) can be accomplished. In addition, a DP2DP-concept also provides an efficient multi-model connection with the hinterland on both sides of a supply chain. As such, from an end-to-end supply chain perspective, the concept can be regarded as an important catalyst for emission reduction. This conclusion is being supported by the study of Lattila, Henttu & Hilmola (2013). They state that the optimal use of dry ports leads to an emission reduction of about 30-40%. However, to take full advantage of the benefits of a dry port, they need to be adequately integrated into seaport hinterland transportation systems and supported by policies and regulations (Regmi and Hanaoka 2012).

From a sustainability perspective, the DP2DP concept is more than just a way to reduce emissions. It also leads to less congestion on roads and, therefore, undesirable, and unsafe situations (especially in densely populated areas) (Bergqvist & Wilmsmeier, 2016). Port areas can be highly congested, of which Jakarta (situated in West Java) is a prominent example. Using rail and/or barge transport from the port to a dry port vice versa means that trucks don't have to access the port area and the city area. Keeping trucks out the port area and the city area helps to reduce the congestion, road accidents, pollution and other type of nuisance.

Conclusions & Discussion

This contribution first provides insight into what a dry port to dry port (DP2DP) concept entails. In addition, it also provides an overview of the key logistics performance indicators in the context of this concept. Finally, the added value of a DP2DP concept is elaborated on for each of the identified performance indicators. It is shown that a DP2DP concept can add value from multiple perspectives. More specifically, the concept enhances the overall performance of a supply chain in terms of reliability, cost, adaptability, delivery speed and environmental sustainability. Nevertheless, broad adoption of the concept is still hampered. In our view, the rollout of DP2DP concepts will not really take off until the following two key conditions are met: First, a DP2DP-concept requires a certain level of maturity of the dry ports involved. In other words, the dry ports must have a proposition that makes them truly perceived as an extension of a seaport. This requires a dry port to offer at least the following services: customs clearance, empty container management, shuttle service and a seamless reliable multi-modal connection with seaport terminals. With this initial requirement in mind, it would be valuable to consider developing a dry port maturity model in a follow-up study. According to Tarhan et al. (2016), a maturity model can be used to assess the current situation, develop and prioritize improvements, and control the progress of the implementation.

Secondly, a Supply Chain Control Tower (SCCT) function must be available. As described in section 2, a SCCT is a centralized solution that provides monitoring capabilities to manage end-to-end supply chain operations efficiently. Without SCCT function, it is impossible to achieve the necessary alignment between the various parties in the supply chain and adequately anticipate disruptions or bottlenecks. To accelerate the use of the Supply Chain Control Towers, it is important to keep an ongoing focus on the 'digital interoperability' between the different parties and digital systems in the supply chain (see e.g. Van Duin et al., 2022).

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