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Effects of demurrage and detention regimes on dry-port-based inland container transport

Stefano Fazi*, Kees Jan Roodbergen

University of Groningen, Faculty of Economics and Business, Nettelbosje 2, 9747 AE Groningen, The Netherlands

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ABSTRACT

Increase of congestion at container deep seaports and shortage of capacity has led inland transport systems worldwide to rely more and more on inland terminals, and on the use of high capacity modes of transport to generate economies of scale and reduce negative effects of trucking. In this setting, planning the transport of maritime containers between a deep seaport and a final inland destination must also consider due dates and soft time windows, the latter known as Demurrage and Detention (D&D). In this paper, we formalize the concept of D&D, model the multimodal planning problem, and assess the impact of different D&D regimes on the emerging inland transport systems. By means of an experimental framework, we compare different D&D policies and provide managerial insights. The experiments highlight the effects of existing D&D regimes on transport efficiency and provide guidelines for their choice in practice. D&D are shown to have a twofold effect: first to limit consolidation opportunities and force the use of trucks as buffer, and second to push containers to dwell unnecessarily at the seaports.

1. Introduction

Increase of congestion at container deep seaports, road traffic and lack of handling capacity has led transport systems worldwide to rely more and more on inland terminals for inland transport. Inland terminals have become a sort of extension of seaports, as containers can be stored and wait here to be picked up. This fact favors the use of high capacity modes of transport, such as barges and trains, against trucking, since containers can be moved more easily in bulk. This concept is also known as “dry port” and has been implemented extensively by several seaports, such as Rotterdam, Los Angeles and Long Beach (Zuidwijk and Veenstra, 2014; Roso, 2007).

Scheduling maritime containers for inland transport entails the trade-off between using primarily high capacity but slow barges or trains, to achieve economies of scale, and the need to be on-time (Zuidwijk and Veenstra, 2014). Additionally, containers, while inland, are subject to soft time windows and related fees provided by shipping lines, who lease the containers to shippers and try to stimulate short return times. In general, for the time a shipper holds a container at or outside the seaport, the container is said to be respectively in Demurrage and Detention. For both conditions, a free period is granted by the shipping line; exceeding it results in a homonym daily fee (Veenstra, 2015).

Many reports indicate that D&D are devised to induce shippers to move their containers out of the seaport terminal areas as quickly as possible. From 2000, some articles reported serious congestion problems at seaports in the USA due to idle containers, which was reportedly dealt with by a decrease in the number of free demurrage days, see Mongelluzzo (2000a,b). In 2005, Leach (2005) reports that Maersk, one of the major shipping lines, announced substantial increases in D&D fees and reductions of free

* Corresponding author.
E-mail addresses: s.fazi@rug.nl (S. Fazi), k.j.roodbergen@rug.nl (K.J. Roodbergen).

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demurrage days as to limit a common behavior of shippers to use seaport premises as storage space. A few years later, Bonney (2015) reports that the Federal Maritime Commission asked for evidence of unreasonable demurrage and detention fees. Nevertheless, the particular structure of D&D is suspected to impact scheduling decisions and to limit the use of high-capacity modes of transport. In this regard, Veenstra (2015) and Ypsilantis et al. (2014) report that D&D can cause a general delay, because it is common for shippers to use all available free demurrage days at the seaport, before initiating inland transport. The motivation is to gain more flexibility during the detention period. Thereby, D&D can reduce opportunities of consolidation, and consequently hinder dry-port-based inland transport.

This paper addresses the following operational problem. Given a set of containers and information on their release and due dates in a time-frame, an appointed local carrier schedules the inland transport from the seaport to the inland terminal, and from the inland terminal to empty container depots. For both transport legs, the decision maker must allocate all containers to the available fleet, *preferably* consolidating and assigning to high capacity means of transport, thus limiting the use of trucks. This allocation problem considers costs reflecting economies of scale and Demurrage and Detention (D&D) costs. Different release and due dates may entail that pairs of containers are incompatible; for example, a late release of one may cause a delay for the other, due to delayed departure. Finally, D&D typically drive the decision on when to move the containers from the seaport (Veenstra, 2015).

In the scientific literature, container systems and related problems have been discussed extensively. See, for example, Vis and de Koster (2003) for a review of operations at container terminals, Christiansen et al. (2013) and Wang and Meng (2017) respectively for review of ship routing and container liner fleet deployment, and finally Konings et al. (2013) for evaluation of container transport networks. In terms of emerging technologies, several contributions have focused on the improvement and control of container logistics in various aspects, based on new concepts and systems. For example, with concern to inland transport, Bhattacharya et al. (2014) focus on an efficient organization of intermodal transport; the proposed system, in a two-step approach, predicts road congestion and assigns the flow to the best transport option. The aim is to reduce excessive use of road infrastructures by better exploiting transport alternatives, such as rail or barge. Nabais et al. (2015) propose a cooperative approach between hub managers and transport providers to better use available transport capacity at hubs, i.e. inland terminals, and in order to achieve imposed modal split goals. The system consists of a predictive model to assess evolving situation of cargo at the hub and of the allocation of cargo to available capacity, constrained by due dates. Similarly, Crainic et al. (2015) and Li et al. (2015) investigate intermodal freight transport planning problems; the former paper defines optimal routes and schedules for vehicles providing transportation services in a dry-port-based intermodal system with a service network design approach; whereas the latter proposes a multi-level freight transport planning approach to assign container flow in a multimodal network.

In this context, D&D have never been directly addressed. The terms are mentioned in a few qualitative studies as a fact, without an in-depth analysis, see descriptions in Frémont and Franc (2010) and Fransoo and Lee (2013). However, recently, Veenstra (2015) emphasized the possible negative impact on inland container transport, thereby hinting towards further investigation. Some papers addressing tactical decisions in container shipping refer to demurrage as an inventory cost (Crainic et al., 2015) or waiting cost (Song and Dong, 2012). The problem is not directly tackled also at an operational level. Mathematical models have been developed to model specific aspects of the transport chain, for example routing of trucks through depots and sea terminals (Zhang et al., 2010), multimodal trade-off decisions (Fazi et al., 2015) and shuttling (Wang and Yun, 2013). Proposed models usually include time windows or due dates, which can be implicitly a means to model the free demurrage and detention periods. However, as is demonstrated in this paper, D&D have a decisive role in the scheduling decisions, and a fixed time window does not properly reflect the interplay between free periods, demurrage fees, and detention fees. Therefore, the presence of an integrated decision scheme that takes the D&D system into account is required.

The aim of this paper is threefold. Firstly, we formalize the concepts of demurrage and detention, describing the system, the stakeholders involved and real-world fees. Secondly, we develop a modeling framework and a heuristic technique to approach a typical transport problem in a dry port setting with different D&D policies. Finally, by means of numerical experiments based on real-world data, we generate insights for practice by exploring the effects of D&D on the dwell times in seaports and the use of sustainable modes of transport, and in general, on the concept of dry port. We also assess the effect of information availability on planning and propose an alternative tariff. As support for this study, we consider the case of the Port of Rotterdam region for which data concerning inland transport is available from a transport provider, owning an inland terminal.

2. Problem setting

The aim of this section is to provide a description of the main dynamics of demurrage and detention (D&D) in relation to a typical inland container transport.

2.1. Setting of inland transport networks

In recent years, inland container transport systems have experienced an evolution in terms of network and supply chain, called regionalization (Notteboom and Rodrigue, 2005). From decentralized and independent systems, seaports are integrating their functions with the hinterland by means of inland terminals. Inland transport networks are increasingly “terminalized” and inland terminals operate as operational buffer with the aim of reducing capacity pressure at seaports, increase throughput and make better use of available land (Rodrigue and Notteboom, 2009; Li et al., 2015).

From an operational point of view, inland terminals act as barge, truck or train operators and provide seamless shuttle services to the seaport (Rodrigue and Notteboom, 2009). Thus, inland terminals establish long term contracts for the constant availability of the