



Detention decisions for empty containers in the hinterland transportation system



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ABSTRACT

In this paper, we study a hinterland empty container transportation system which consists of a sea container terminal and an inland container terminal. There are a hinterland container operator who is in charge of the hinterland container transportation and an ocean carrier who has an empty container depot at the sea container terminal. We utilize a two-stage game model to describe the ocean carrier's decision about the container's free detention time and the hinterland container operator's decision about the time when should an arrived empty container at the inland terminal be dispatched to the sea terminal. Optimal delivery policy of the empty container and the ocean carrier's optimal free detention time are derived. It is shown that the decentralized system does not guarantee system coordination all the time. The ocean carrier has incentive to integrate the hinterland transportation operation only if the hinterland area is not very short of empty containers.

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1. Introduction

With the development of the production regionalization and economic globalization, the international trade has been booming in the past few decades. The import and export freights in the international trade are mainly distributed by maritime transportation. The ocean container transportation is now dominating the maritime transportation system, with over 50% the value of the international trade cargo (Review of maritime transport, 2016). The performance of global supply chain depends crucially on the efficiency of the ocean container transportation system. In the global distribution channel, the consignor is the one who sends the cargo for ocean transportation, the consignee is the one who is receiving the cargo in the containers, the shipping liner (or ocean carrier) is the shipping company that is in charge of the cargo ocean transportation, and the container terminal operator is the company or organization that provides container operation services in the container terminal. There are two kinds of hinterland operation mode for containers, carrier haulage and merchant haulage. In the carrier haulage mode, the shipping liner is responsible for the hinterland transportation and storage and containers are under the shipping liner's control in the whole process. In the merchant haulage mode, there is a hinterland container operator who is in charge of the containerized freight transportation and operations in the hinterland. Under the merchant haulage mode, the shipping liner loses the control over the container in hinterland and will charge container charter fees from the hinterland container operator (so called demurrage and detention fees which will be defined later).

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Table 1

The demurrage and detention free days for train or barge transport compared with truck transport in the Port of Rotterdam (Storm, 2011).

Shipping line	Demurrage	Detention free days		Combined free days	
	Free days	Truck train/barge		Truck train/barge	
Maersk	3	3	5		
MSC				3	7
CMA CGM				7	7
COSCO				7	7
Hapag Lloyd	5	2	6		
Evergreen	3	2	6		
APL	5	3	6		
CSCL	3	2	10		
Hanjin Shipping	4	5	5		
MOL	3	3	5		
Nyk Line	4	6	6		
OOCL	3	2	6		
CSAV	4	6	6		
Yang Ming	4	3	3		

Participants in the global container supply chain, including the hinterland container operator, the shipping liner and the container terminal operator, are all trying to enhance the operation efficiency and the service level so as to pursue high competitiveness. Operational approaches are emphasized and well developed, for example, container terminal crane scheduling and space allocation, collection and delivery arrangements of the hinterland container operator, and the ocean carrier's trade lane setting and route scheduling. Fransoo and Lee (2013) noted that there are many significant strategic problems that are underestimated, such as those concerning contracting, pricing, capacity development and risk management in the global distribution channel.

There are extensive studies about the empty container repositioning in both the seaborne level and the hinterland level. Seaborne empty container repositioning mainly involves the empty container sharing, leasing and transportation between different sea ports. The hinterland empty container repositioning includes the transportation and management of the empty containers in the hinterland so as to fulfill the empty container with the demand of export cargos and prevent unnecessary movements of the empty container in the hinterland.

In this paper, we consider a hinterland empty container transportation system in an export-oriented port area (for example, in the port area of China, the export cargo volume is higher than the import cargo volume and the empty container utilization in the hinterland is high) which consists of a sea container terminal and an inland container terminal. The ocean carrier has an empty container depot at the sea container terminal. There is a hinterland container operator who is in charge of the hinterland container transportation. When selecting port services, consignors and shipping liners are emphasizing the performance of the container supply chain rather than the port itself. The efficient hinterland accessibility is important in the port competition. Inland container terminals help to keep the hinterland accessibility of the seaports and provide a cost efficient and reliable alternative to truck transportation (Konings et al., 2013).

Once an imported container is unloaded from the vessel at the sea container terminal, the ocean carrier loses the control of the container and will start to charge demurrage fee and detention fee for the container (Deidda et al., 2008). Demurrage is related to the time range that a container spends at the sea container terminal, namely from the time an inbound container arrives at the sea terminal to the time it is moved out of the sea terminal by the hinterland container operator. Detention is related to the time range that a container spends in the hinterland, namely from the time it leaves the sea container terminal to the time it is sent back to the sea container terminal (the sent back container could be laden or empty). The ocean carrier will charge the consignee a demurrage fee per container per day if the demurrage exceeds a specific free time. The ocean carrier only counts the time the container spends in the sea container terminal without being affected by the ownership and operations in the sea container terminal. Similarly, a detention fee per container per day is charged by the ocean carrier if the detention exceeds a specific free time (so called free detention time). The detention and demurrage fee are also applied to the export process. These fees are not directly paid by the consignor or the consignee to the ocean carrier but paid through the hinterland container operator. Table 1 shows the demurrage and detention fees in the Port of Rotterdam. As shown in Table 1, to encourage the barge and train transport in the multi-modality hinterland transportation system, some ocean carriers provide longer free time for the detention and demurrage under these two transport modalities.

The charging scheme that includes a "free-time" and an overtime-fee is also used by other players in the maritime transportation system, such as the sea container terminal operator. For the inbound containers that are unloaded from the vessels to the sea container terminal, the terminal operator will charge a storage fee per unit container per day if the container dwell time in the terminal exceeds a certain free-time (Yu et al., 2015; Kim and Kim, 2007). This kind of fee is charged by the sea container terminal operator for the occupation of storage space in the terminal yard. Differently, the demurrage and detention fees studied in our paper are charged by the ocean carrier for losing the control of containers.

After unloaded from vessels, inbound containers will be moved from the sea container terminal to the consignee in hinterland by the hinterland container operator. Becoming empty at the consignee, some empty containers are moved to

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