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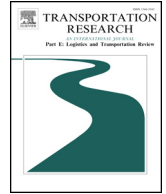
Hinterland transport chains: A behavioral examination approach

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ABSTRACT

A hinterland transport chain is the transport network on the landward side of a seaport, over which cargo moves to/from the seaport. A hinterland transport chain choice is jointly determined by seaports, dry ports, intermodal carriers, importers and exporters. In this paper, determinants of sea/dry port choice, shipper choice and intermodal carrier choice are deduced to also be determinants of hinterland transport chain choice. Furthermore, a behavioral model is presented that describes the joint choice of a hinterland transport chain, accounting for each of the above parties' objectives: sea/dry ports seek to maximize throughput; intermodal carriers seek to maximize profits; and shippers seek to minimize logistics cost. The behavioral model is used in the analysis of unexplored areas in the hinterland transport chain literature, i.e. the fundamental issues of the existence and uniqueness of such chains.

1. Introduction

A hinterland is the landward side of a seaport. A cargo seaport's hinterland is "the scatter of inland points of cargo origin/destination generating the traffic flows passing through a specific port" (Ferrari et al., 2011, p. 382). The selection of a cargo seaport by shippers will depend upon the services and the quality of the services provided by the seaport.

Whereas the seaport is a sea node of a hinterland network, a dry port (known as an inland port in the U.S.) is an inland node of a hinterland network (Roso et al., 2009, p. 341). A dry port in addition to providing transshipment cargo service may also provide other cargo services such as storage, consolidation and customs clearance. The latter is a core function of China's dry ports (Beresford et al., 2012).

If a seaport experiences congestion in handling hinterland cargo, the hinterland's dry port could be used to eliminate or reduce this congestion (Cullinane et al., 2012, p. 2). A dry port may be described as an extended gate of a seaport (Veenstra et al., 2012). Lättilä et al. (2013) also found that the usage of dry ports can reduce both the cost and CO_2 emissions in drayage.

"A hinterland transport chain is a transport network over which: (a) cargo imported into a hinterland via its seaport is transported by an intermodal carrier from the seaport to an importer in the network or to the network's dry port and then to the importer and (b) cargo exported from the hinterland is transported by an intermodal carrier from the exporter in the network to the network's seaport or to the network's dry port and then to the seaport" (Talley and Ng, 2017, p. 175). Recently, Talley and Ng (2017) examined the determinant effects on a hinterland transport chain. While the reported findings provide valuable new insights into how certain determinants can both directly and indirectly impact the choice of a hinterland transport chain, the model lacks a behavioral foundation.

To complement Talley and Ng (2017), this paper adopts a behavioral approach, i.e., using the theory of variational inequalities

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and game theory (Nagurney et al., 2002; Nagurney, 2006) to examine hinterland transport chains. Using this alternative approach, unexplored areas in the hinterland transport chain literature will be examined. Particularly, we will present a game theory based behavioral model that can answer fundamental questions regarding the existence and uniqueness of hinterland transport chains. The model also provides a starting point to numerically forecast the impact of policy changes and practices on freight flow in the hinterland transport network.

The remainder of this paper is organized as follows. In Section 2, it is deduced via a series of propositions that determinants of seaport/dry port choice, intermodal carrier choice and shipper choice are also determinants of hinterland transport chain choice. The preliminaries for the proposed equilibrium model are outlined in Section 3, followed by Section 4 where the development of a behavioral model for a hinterland transport chain and the discussion of the existence and uniqueness of such a chain are presented. Finally, conclusions are presented in Section 5.

2. Deducing determinants of hinterland transport chain choice

Sea/dry ports can affect the cargo provided to them by intermodal carriers (e.g., railroad, truck and inland waterway carriers) by having contractual arrangements with these carriers to call at their sea/dry ports and delivery of a minimum amount of cargo over time. (In this paper, it is assumed that sea and dry ports have the same objective, i.e. maximizing their hinterland chain throughput, cf. Section 3.) In return, the intermodal carriers would be charged lower port charges and/or receive other benefits. These benefits are not only determinants of intermodal carrier choice by sea/dry ports, but are also determinants of the throughputs of sea/dry ports.

Proposition 1. *Determinants of intermodal carrier choice by sea/dry ports are also determinants of hinterland transport chain choice by sea/dry ports.*

Proof. Since hinterland transport chain choice by a sea/dry port is a function of sea/dry port throughputs and since these throughputs are functions of the determinants of intermodal carrier chain choice by sea/dry ports, it follows by deduction that hinterland transport chain choice by sea/dry ports is a function of the determinants of intermodal carrier chain choice by sea/dry ports. □

Note that sea/dry ports undertake actions with respect to intermodal carriers (e.g., contracts) that result in (and thus are determinants of) throughput increases via these carriers in the hinterland transport chain.

The amount of cargo that shippers are willing to transport by intermodal carriers to and from sea/dry ports can be affected by local and regional governments providing economic incentives, e.g., lowering property taxes to attract the construction of large-retail-firm distribution centers. In response to the lower-property-tax incentive, 220 distribution centers have been built in the U.S. state of Georgia, contributing to its Port of Savannah being ranked (via container throughput) the second largest container port on the U.S. East Coast.

Proposition 2. *Determinants of shipper choice by sea/dry ports are also determinants of hinterland transport chain choice by the sea/dry ports.*

Proof. Since hinterland transport chain choice by sea/dry ports is a function of sea/dry port throughputs and since these throughputs are functions of the determinants of shipper chain choice by sea/dry ports, it follows by deduction that hinterland transport chain choice by sea/dry ports is a function of the determinants of shipper choice by sea/dry ports. □

Proposition 3. *Determinants of sea/dry port choice by intermodal carriers are also determinants of hinterland transport chain choice by intermodal carriers.*

Proof. Given that hinterland transport chain choice by an intermodal carrier is a function of its hinterland transport chain profit and under the reasonable assumption that this profit is a function of the determinants of sea/dry port choice by the intermodal carrier, it then follows that hinterland transport chain choice by an intermodal carrier is a function of the determinants of the sea/dry port choice by an intermodal carrier. □

Proposition 4. *Determinants of the sea/dry port choice by shippers are also determinants of hinterland transport chain choice by shippers.*

Proof. Given that hinterland transport chain choice by a shipper is a function of its hinterland transport chain logistics costs and under the reasonable assumption that these logistics costs are a function of the determinants of the sea/dry port choice by the shipper, it then follows that hinterland transport chain choice by a shipper is a function of the determinants of the sea/dry port choice by the shipper. □

3. Hinterland transport chain: behavioral assumptions

In order for a hinterland transport chain to exist – sea/dry ports, intermodal carriers and shippers must be in agreement with the choice of the chain. In choosing whether to join a hinterland transport chain: (a) sea/dry ports will seek to maximize their hinterland chain throughputs, (b) intermodal carriers will seek to maximize their hinterland chain profits (Lam and Gu, 2016; Lun et al., 2016) and (c) importers and exporters will seek to minimize the hinterland chain logistics costs of their cargoes.

In order for a hinterland transport chain to exist – sea/dry ports, intermodal carriers, and shippers (i.e., importers and exporters) – must be in agreement with the choice of the chain.

The choice variable used by an intermodal carrier (sea/dry port) in determining its maximum hinterland chain profit (maximum