The Interport: A Logistics Model and an Application to the Distribution of Maritime Containers

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ABSTRACT
In a container transportation and logistics network, an interport is a common user facility located in the hinterland of one or several seaports where services are available to carriers and shippers such as transshipping, customs clearance and inspection, temporary storage, tagging, and sorting. Interports pose opportunities and challenges for operators involved in freight transport and trade. Mathematically, the authors identify the “interport model” as an extension of the conventional transshipment problem in a hub-and-spokes configuration with the interport treated as a novel kind of hub. The model highlights the advantages that shippers may enjoy in routing their containers from the seaports to their final hinterland destinations via one or several interports. They also discuss an empirical application portraying the intermodal transportation network in the Campania region, Italy. The major seaports of the region are Naples and Salerno; the recently constructed terminal, warehousing and processing facilities at Nola and Marcianise are recognized as interports. A linear programming model minimizes the sum of all container-related logistic costs throughout the entire network, including customs inspection, handling, and storage costs. The solution demonstrates the critical role of adequate customs facilities at the interports, and adequate railway connections between the seaports and the interports.

Keywords: Containerization, Customs, Dwell Time, Generalized Total Logistic Cost, Hub-and-Spokes Distribution Network, Intermodal Transport, Interports, Port-Hinterland Logistics, Regional Logistic System, Seaports

INTRODUCTION
The huge expansion in international trade during the last 50 years (facilitated and propelled by the invention of the standardized container as a medium of transport) has led to overcrowding of port facilities world-wide and growing pains in logistic systems handling the customs examination, storage and distribution of containers. Such congestion sometimes leads to intolerable conditions: mountains of inventories awaiting customs clearance, rail connections being choked, and terminal facilities at ports burgeoning. Various means of easing port congestion have been proposed and implemented at different locations, such as the upgrading of existing port and warehousing facilities, and the construction of entire new seaports.
In this paper, we report on a daring innovation currently under way in the Campania region in Italy, supporting the container traffic through the ports of Naples and Salerno: the building from scratch of new inland off-dock handling facilities called interports, offering off-port customs examination, storage of load units, reloading of cargoes from rail to truck transport (and vice versa), warehousing and distribution of goods. The interport at Nola (a name that the student of Roman times will easily recognize) is mainly completed, the facilities at Marcianise are still being developed.

The deplorable conditions at the port of Naples are notorious: delays of imported containers up to several weeks are not uncommon. The port sits between the old classical city and the sea, with no scope for local expansion in the short term. The long-time goal of the interports is to move most of the existing container handling and storage to the hinterland of the city, where land is plentiful and access is easy. Centuries-old dilapidated port areas are taken over by gleaming brand-new inland logistic facilities serving the container traffic. This is all made possible by the availability of customs clearance at the interports, offering shippers the opportunity to off-load arriving containers at the seaport directly onto bonded and sealed railway trains bound for the interport.

To analyze the resulting logistic system, we propose a novel mathematical model type: the interport model. Generically, it is an off-spring of the well-known hub-and-spoke model (Thore & Iannone, 2005). The interport is a hub inserted into an existing transshipment network. The hub is here combined with a characteristic switching facility: shipping a container along one of the available spokes leaving the seaport, the shipper will have to make a zero-one decision whether to seek customs examination immediately, or to have it delayed until the interport. To model these zero-one decisions, we shall actually distinguish two interports nodes: the customs facility, and a plain logistic facility available to all comers.

The interport model is a multi-commodity, multi-modal linear programming model of a container distribution system that includes seaports, interports, and inland locations. The present paper only deals with imported containers, in a subsequent study we shall examine the flow of exports via interports. The costs incurred along the network are direct and indirect logistic costs. Direct costs are not only transportation rates but also typical costs arising at ports and interports: customs inspection costs and terminal operation costs (including handling charges, and demurrage charges for temporary storage after the free time). Indirect costs include in-transit inventory holding costs and container leasing costs, which are calculated in function of the time for logistic operations. The model optimizes the distribution of containers in the port-hinterland logistic system, minimizing total costs. The problem at hand is to determine the flow of containers that would lead to the lowest total inland costs subject to physical balancing conditions at all traffic nodes, and capacity constraints over all railway links. In particular, the model determines the transshipments through the interports, and the scope for their further expansion.

From a more general perspective, the construction of an interport is an example of a Schumpeterian innovation, dramatically changing the layout and flow of shipments of imported and exported goods into/from a country, aiming at relieving congestion at the seaports. It involves huge investments in infrastructure, installing high-tech equipment like automated stacking and storage equipment and advanced logistic control systems.

**Antecedents**

A variety of optimization and simulation studies are available in the container transportation literature. Cullinane, Ping, and Wang (2002) employed a single-commodity, multimodal and multiobjective programming capacitated programming model to simulate, based on time and cost criteria, the optimization of the flows of full containers imported to China. Luo and Grigalunas (2003) developed a spatial economic, multimodal simulation model dealing with the
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