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Development of models predicting dwell time of import containers in port container terminals – an Artificial Neural Networks application

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Abstract

The general aim of this paper is to propose the development of a methodological framework that incorporates the various factors affecting the Dwell Time (DT) of containers in container terminals. Container terminals are regarded as a key element of logistics chains since they are a link between sea and the hinterland transportation modes. Workload forecasting is essential when it comes to truck arrivals for the avoidance of bottlenecks and the smooth integration of container terminals in the supply chain. Terminal operators, tend to make stacking decisions based on mostly on factors suc the container's weight, size and type. The suggested methodology requires the collection of aggregate data and the application of Artificial Neural Networks (ANN) to identify the determinants of Dwell Time (DT). The first results of the ANN showed that the most important factors affecting significantly the model's accuracy are the following: containers size and type, the day and month of the container's discharge, the vessel's port of origin and the commodities transported.

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Keywords: Dwell Time; import container; marine container terminal; Artificial Neural Network; decision making; teminal policies

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1. Introduction

Marine container terminals constitute a key node in global supply chains. A container terminal is the area where containers are handed before being exported in other countries or imported in the port mainland. The main transportation modes that can be found in a container terminals are vessels for deep-sea or short-sea transportation, barges for inland water transportation, trains and trucks for hinterland transportation. Hence, terminals serve as buffer zones that absorb any incompetencies and delays created in other parts of the supply chains.

Simultaneously world container traffic, defined as the absolute number of containers carried by the sea, increased from 28.7 million TEU's in the 90's to 136 million TEU's in 2008 when the world economic crisis started. World marine container terminal throughput increased from 36 million TEU's in the 80's to 88 to around 623 million TEU's in 2012 Notteboom (2014). Between the years 1997 and 2008, global container trade presented an average growth of 9% per year. Nowadays, due to the enlargement of vessel size, shipping industry is facing remarkable structural changes. For example, the construction of new ships with a capacity of more than 19,000 TEU's, such as MSC_OSCAR with a total loading capacity of 19,224 TEU's and CSCL_GLOBE with a loading capacity over 19,000 TEU's, are part of the abovementioned problem. Hence, the new ship's size imposes a challenge not only on a marine container terminal level but also to the entire supply chain.

Marine container terminals are regarded as the primary regulators of efficiency and reliability of the supply chain since they can absorb any delays and bottlenecks are created in other parts of the chain (Rodrigue et al, 2008). With containers being the dominant transportation unit of a fast growing shipping industry, terminals are challenged to cope with an increasing number of boxes that need to be handled quickly, efficiently and economically (Rodrigue and Notteboom, 2009).Therefore, marine terminals have to optimize their procedures in order to deliver containers on time and without any damages.

Apart from challenging port efficiency the ever-growing container volumes confront terminal capacity. It is a common policy of many shippers to keep their cargoes in the terminal yard mostly taking advantage of the free storage days. The lack of available space for the expensive investment of terminal expansion, forces terminal operators to implement new policies such as financial penalties or various operational restrictions to make shippers and consignees discharge containers faster (Rodrigue et al., 2008).

Several studies have illustrated that improvement on information regarding trucks' arrivals to pick-up import containers could result in an important reduction of unproductive moves (Goodchild and Noronha, 2010). The movement of a container from its first stacking place in the yard for whatever a reason but the delivery or customs inspection is defined as an unproductive more. The number of unproductive moves is often used to access a terminal's efficiency. Therefore, it could be argued that the precise and timely prediction of the daily rate of discharge for import containers is significant for the scheduling of the optimal stowage planning of containers in the yard and for the correct allocation of handling equipment and human resources. Several container marine terminals have tried to implement various methods like truck appointment systems but without having the expected results. However, the precise prediction a container's dwell time and pick-up time-of-day could provide an input and help yard planners stack the containers in such a manner that the containers with the higher pick-up probabilities could be retrieved easily and without many unproductive moves.

To the best of our knowledge, although there is a substantial literature focusing on factors affecting freight mode and route choice, limited scientific interest is presented regarding to the factors that affect the containers' Dwell Time (DT). The innovation of this paper is to study these aspects of the logistic chains within a container terminal and to create a methodological framework able enough to predict the container dwell time and to provide yard planners and terminal operators with a forecasting tool that will assist them when making daily decisions regarding stacking policies, optimal equipment and human resources allocation.

This paper is structured as followed: After introduction the existing literature on DT prediction is presented. In section 3 the input data and the methodological framework are extensively described. Section 4, presents the data input for the model development. Section 5 discusses the model estimation results. The paper concludes by identifying the implications of the research on terminal operations when the exact DT of an import container is to be predicted and suggests more areas for further research.