MODELING AND OPTIMIZATION OF GENERAL CARGO PORT OPERATIONS THROUGH FUZZY MINIMAL SPANNING TREE AND FUZZY DYNAMIC PROGRAMMING APPROACHES

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Abstract. *General cargo handling is of special importance because it generally corresponds to most of the costs incurred by the loading and unloading of ships at port. This study addresses the loading process of general cargo-type export products. The theoretical structure of a general port optimization model is described, and an optimization model is applied to a general cargo port located at the Marmara Sea in Turkey as a real-world case study. The main objective of this study is to display the methodology for increasing the ship loading rate. The present ship loading rate is measured as a baseline, and the factors that affect the baseline loading performance are identified. Simulation and statistical techniques such as hypothesis tests and correlation analyses are used to optimize equipment and verify variables. The problem is solved with minimal spanning tree and dynamic programming models. These models are integrated with fuzzy methods to tackle uncertainties in the data. The results of the models are compared, and sensitivity analysis is applied to each mathematical model.*
Keywords: General cargo, Ports, Transportation management, Fuzzy sets, Fuzzy minimal spanning tree, Fuzzy dynamic programming, Simulation

1. **Introduction.** Marine ports always play a strategic role in the development of domestic and international trade. Port-generated economic activities include shipping and related enterprises, trade services, inland transportation, and cargo and ship activities. Since goods can arrive in different forms such as dry and liquid bulk cargo, containers, general cargo, and so on, cargo handling in ports is a major activity of transport operations. Among those activities, general cargo handling is of special importance because it generally corresponds to the highest costs incurred by ship loading and unloading at port. For this reason, this study addresses the loading process of general cargo-type export products.

There are many studies related to the management of the port operations mentioned above; some recently published studies are mentioned here. Lee et al. [1] applied the framework of supply chain modeling and analysis to the port industry supply chain by using a simulation approach. Ha [2] presented a comparative evaluation of operation quality factors at 15 major container ports across the world. Bichou and Gray [3] noted the widespread recognition of the potential of ports as logistics centers and the fact that widely accepted performance measurements for such centers have yet to be developed. Hartmann [4] introduced an approach for generating scenarios of seaport container terminals. These scenarios can be used as input data for simulation models. Bielli et al.