Hybrid Berth Allocation for Bulk Ports with Unavailability and Stock Level Constraints

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Over the past decades, the tonnage of bulk cargo carried by sea shipping has increased sharply. Based on Sirimanne et al. (2019), in 2020, the international dry bulk trade and tanker trade was 8.085 billion tons, accounting for 75.9% of the world's total cargo load. The ever-growing demand makes efficient loading or discharging of vessels a great challenge, and it has generated many research interests recently. Generally, the Berth Allocation Problem (BAP) is concerned with the optimal decisions on assigning a berthing position and berthing time to the calling vessels. Operation Research (OR) methods and techniques contribute significantly to the BAP in container ports and provide strong managerial support for port managers Steenken et al. (2004) and Stahlbock & Voß (2008). However, research dedicated to BAP in bulk ports has received relatively little attention. Although the BAPs in bulk ports are similar to those in container ports, some unique characteristics differentiate them. A significant difference is that the bulk vessels can only be allocated to the berthing position where the installed handling equipment can serve the cargo type on the vessel. In other words, berth assignments at bulk ports are more restrictive than container ports. Umang (2014) establish innovative models and solution algorithms specifically for BAP in bulk ports, which highlights the specific features of bulk port operations, that is, the cargo type of vessels and the equipped handling facilities of berths. Furthermore, the cargo type restricts the berthing position and influences the service starting and completion time. For instance, specific cargo can be discharged from the vessel only when its storage places can accommodate the corresponding quantity. Barros et al. (2011) model stock level constraints but not consider the time-variant property of the stock that is changing with the loading or discharging process.

Besides, Krimi et al. (2020) and Ribeiro et al. (2016) stress that the unavailability of berths frequently appears in practice because of extreme weather or maintenance requirements. However, few studies have focused on the BAP model for bulk ports with stock level restrictions, let alone combing it with unavailability considerations. This paper presents a Mixed-Integer Programming (MIP) model for the hybrid BAP in bulk ports, which explicitly considers the constraint of time-variant stock level and practical unavailability. We use the commercial software CPLEX to obtain solutions for a set of instances, and the results show the effectiveness of the proposed model.

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