

Appendix A. NP-hard proof.

BAP is recognized as NP-Hard [6,36], and the combinatorial optimization model presented in this study is more complex than a single berth allocation model. Consider special cases of the proposed problem where the number of SSE facility and terminal labor crew are equal to 0. Furthermore, the number of quay cranes is equal to $+\infty$ ($|Q| = +\infty$) and the maximum number of quay cranes allowed to assign to vessel i is equal to $+\infty$ ($q_i^{\max} = +\infty$). Then the BAP can be solved in polynomial time if this instance of the proposed problem can be solved in polynomial time. Therefore, we can conclude that the proposed problem is NP-Hard.