

# Marine Fleet and Container Transportation in Marine Terminals and Its Effect on Increasing Products

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## Abstract

*The purpose of this study is to investigate how product volume is affected by container transit in sea terminals. A two-objective mathematical model for container transportation was developed based on this study's innovative goals and hypotheses. The main objective of this concept is to reduce the time and expense of transportation. Parametric sensitivity analysis was performed on several model parameters to evaluate the resilience of the model. According to the analysis, parameter adjustments have a greater influence on the time objective than the cost objective. This result implies that time-efficient container transportation optimization is more susceptible to changes in the parameters than cost-efficient optimization. This study emphasizes the importance of concentrating on time-related aspects while organizing and overseeing container traffic in maritime terminals. Sea terminals may be able to handle more products with improved efficiency and possible volumes. These observations can direct future advancements and enhancements in the management of seaport operations, emphasizing the necessity of a well-rounded strategy that considers time and money, with a focus on the variables affecting time efficiency.*

**Keywords:** Container shipping, sea terminal, products, chemistry, cost

## INTRODUCTION

The advancement of technology has made sea container terminals complex infrastructures to manage, so this should be studied and investigated by analysts and transportation experts to improve the efficiency and performance of container terminals. However, the large number and variety of logistical activities gathered is a major obstacle to effective decision making. In most cases, the logistic processes in this field are NP-hard problems. In addition, operators and managers face uncertainty regarding the arrival and departure of containers and changes in shipping information. The existence of uncertainty and inaccuracy in logistics processes should be explicitly considered as much as possible. Several groups are involved in transporting goods through the containers. Carriers and operators transport goods from sender to consignee. Today, to realize the efficiency and effectiveness of logistics needs, freight companies and logistics groups as customer partners have paid more attention to this and have found that from the point of view of the sender of the goods, the efficiency and effectiveness of the entire chain is more than the efficiency and effectiveness of just one chain. In a situation where the supply

chain plays a competitive role, all other groups benefit. It is expected that this study will provide a platform that will lead to a reduction in the time required for the clearance of containers in the terminals, thereby improving the performance of the terminals, reducing executive and operational costs, and providing customer satisfaction.

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## RESEARCH BACKGROUND

Taghipour et al. [1] examined and projected Iran's container transport market from 2012 to 2019. The report highlights the fierce competition

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that exists in the marine transportation business to capture as much market share as possible and to strengthen its competitive position. Research has found a unique place in the meantime since failing to advance with strong and comprehensive knowledge and information will lead to the achievement of the stated aims.

Taghipour et al. [2] examined the container transportation services and customer challenges in the maritime transportation sector. This study focuses on the issue of transportation because it has a significant impact on the final price of goods in developing nations, which has garnered significant attention in the field today. Free trade and an atmosphere of intense competition among raw materials and industry owners have become essential.

Taghipour et al. [3] studied the effective elements that container transport companies can use to increase customer satisfaction. This study examines the duration and timing of transportation, particularly maritime transportation, as a significant number of cargoes are transported in this manner and must arrive at the production line and end-user on time, at the appropriate location, and in a timely manner.

The position of ports and maritime transportation has been described by Vedadi [4] in an article titled Future: The approach and predisposition to future conditions, as well as the implicit and direct components of this association, have all been explained as an attempt at foresight in time and place. The findings highlight the necessity of including port development in the investment agenda to raise port infrastructure standards and to make ports more compatible with the container model.

Azandriani et al. [5] examine the market structure of investment activities at container ports. This study uses Herfindal's quantitative index of market structure from the perspective of monopoly or competition to analyze the current demand for private sector investment in national ports with regard to port development and moving towards third-generation ports.

Asiaber et al. conducted a statistical analysis of the variables influencing container clearance in Iranian ports [6]. The nation's marine transportation sector must undergo extensive expansion to compete internationally, increase its market share, and support local sectors in their fight against foreign rivals.

To use a local methodology, Heydari et al. [7] examined the concept of development and provided an overview of solutions from the perspective of Shahid Rajaei port container terminal managers. A portion of the experiences in the development section is extracted and presented in the form of a mental map of the managers in this area.

By offering an approach based on statistical theory, Kim and Hong [8] attempted to estimate the number of displacements that remained for a block of containers to provide a straightforward solution. They achieved a significant reduction in the time required to find a solution by using a branch-and-bound approach.

Caserta et al. [9] devised a dynamic approach to address problems of greater magnitude. They then contrasted their findings with the technique proposed by Kim and Hong [8] to address larger difficulties. This suggests substantial advancement.

Forster and Bertfeldt's study [10] is among the most recent studies on this topic. Based on whether the containers obstructed the container path with a higher priority, they separated the containers into two categories: good and bad. Based on this classification, six displacements were defined. They provided an algorithm based on the branch-and-bound technique, moving the containers while looking for better solutions and paying attention to the priorities they took into account for the various movement scenarios.

Among the few studies that consider the objective function of lowering the crane's operating time are those by Anluwert and Aydin [11]. They offered several novel algorithms to address this issue and assessed each algorithm's effectiveness in relation to the best solution produced by a branching algorithm. In any event, the study's samples only addressed the situation when there was a group with few dimensions, at most six columns and seven heights.

Lee and Chao [12] introduced a local search algorithm to address the container-sorting problem. The algorithm generates an initial solution and numerous random paths through multiple iterations at each stage and then uses an M mathematical heart to select the optimal combination of the generated routes.

## **MODEL**

Sea transportation is very important from the point of view that it includes a high share of transportation.

The problem investigated in the present study is the scheduling of container operations in three parts: transportation, accumulation, and loading on a crane. There are two types of containers: input and output. The incoming containers are first entered into the warehouse and stacked, and then the corresponding containers are transferred to the transportation department, after which they enter the crane stage, and their loading is performed considering that the possibility of stacking, transportation, and simultaneous loading of two containers does not exist. Therefore, we are faced with the limitation of preferring one container over another, which may be subject to a fee. Here, the goal is to choose the best replacement of containers in all three stages of accumulation, transportation, and loading in such a way that both the imposed cost and time of the entire process are minimized.

## **SOLUTION METHOD**

### **NSGA-II Algorithm**

The NSGA-II algorithm is a multi-objective genetic algorithm designed based on non-dominant solutions. Thus, in the single-objective genetic algorithm, only one objective function is considered as the fitness function, and its decision variables are entered into the chromosome as genes and form the initial population. However, our NSGA-II algorithm has several objectives that are designed to solve multi-objective problems.

## **MODEL VALIDATION AND SOLUTION**

The first stage of solving the model is validated. First, the model is introduced in different dimensions, and then, the results of its solution are explained. The dimensions of the model are listed in Table 1.

To complete the validation results, two important parameters were removed from the model: the fines and transportation time. Removing these parameters should logically improve the answers in terms of both cost and time. To reduce both parameters, this action is presented in Table 2, and the results are presented in the following graphs.

As can be seen, by removing the fine, the cost has been reduced to some extent, but the reduction is greater in the removal of the transportation time. By removing these two parameters, the cost tends to improve and decrease; thus, the effect of removing these two parameters on the cost was proven Figure 1

### **Penalty and Transport**

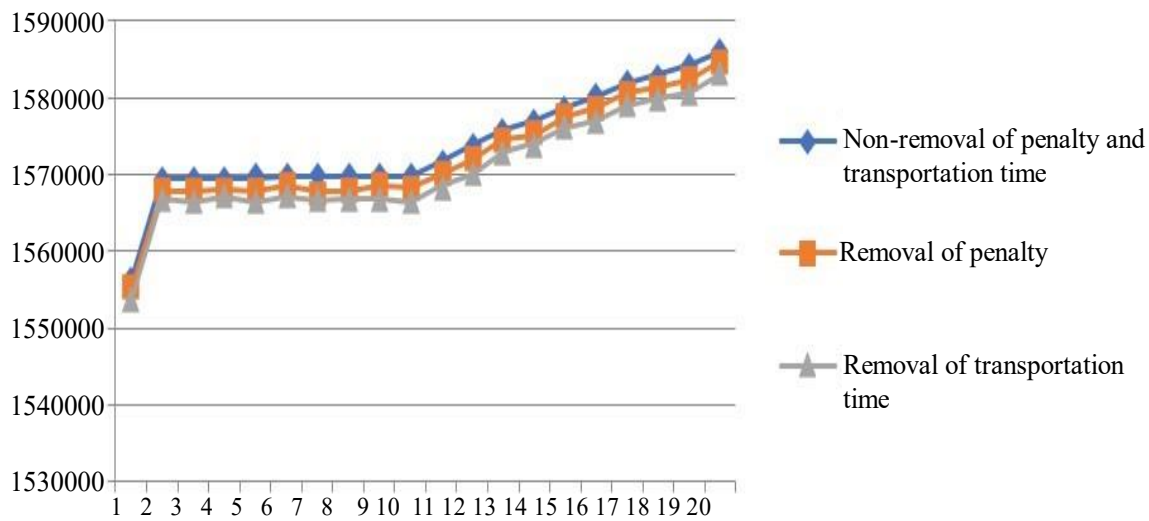
1. Non-removal of penalty and transport time
2. Penalty removal
3. Removal of transport time

**Table 1.** Dimensions of model.

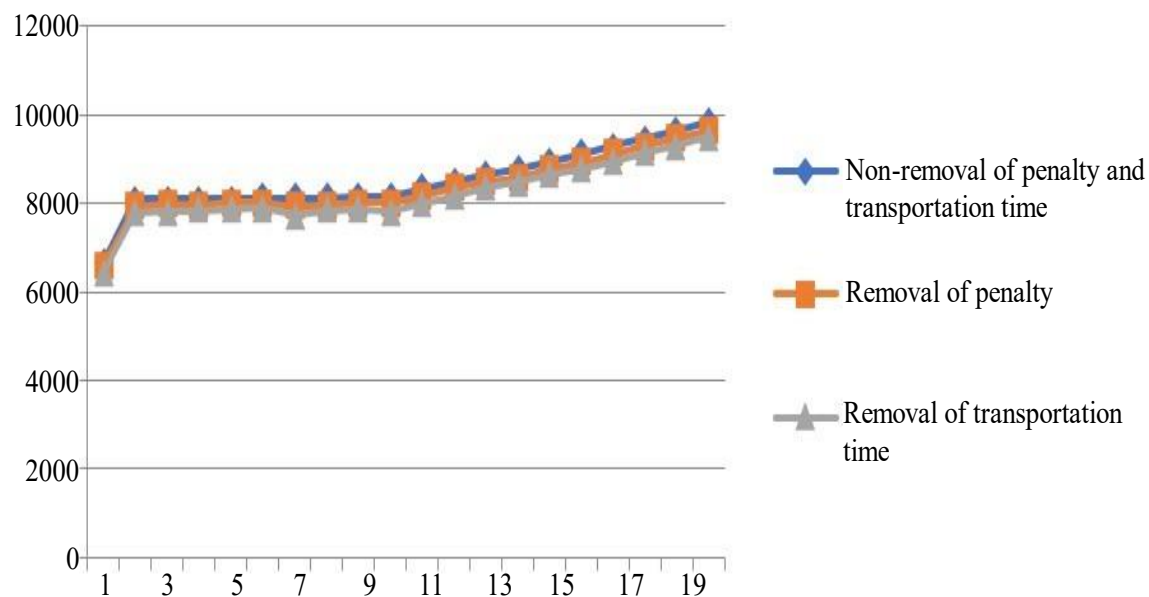
The issues	Incoming containers	Output containers	Store	Transportation department	crane
1	5	5	1	1	1
2	6	6	2	1	3
3	7	6	3	1	5
4	8	7	4	2	7
5	8	8	5	2	9
6	9	8	6	2	10
7	9	9	7	3	11
8	15	15	8	3	12
9	20	20	9	3	13
10	25	23	10	4	14
11	28	25	11	4	15
12	30	30	12	4	16
13	35	30	13	5	17
14	37	33	14	5	18
15	40	35	15	5	19
16	45	40	16	6	20
17	45	45	17	6	20
18	47	45	18	6	20
19	48	46	19	7	20
20	50	50	20	7	20

**Table 2.** Validation results of solving the model in large dimensions by removing penalty and transportation time.

Failure to remove fines and shipping time		Remove the penalty		Eliminate shipping time	
Cost	Time	Cost	Time	Cost	Time
1556404	6663	1555220	6560	1553654	6416
1569418	8101	1567834	7907	1566782	7769
1569471	8104	1567858	7996	1566260	7815
1569536	8105	1568051	7959	1567051	7829
1569623	8107	1567783	8007	1566379	7866
1569679	8114	1568498	8007	1567143	7898
1569690	8117	1567703	7918	1566629	7747
1569706	8124	1567935	7931	1566808	7831
1569751	8131	1568561	8022	1566919	7841
1569831	8140	1568373	8008	1566414	7819
1571817	8336	1570056	8168	1568468	7981
1573756	8470	1571856	8337	1570121	8153
1575756	8633	1574553	8492	1572865	8372
1576970	8769	1575206	8571	1574061	8465
1578691	8944	1577420	8755	1576021	8642
1580205	9110	1578827	8910	1576949	8771
1581933	9291	1580575	9117	1578958	8926
1582982	9457	1581309	9296	1579842	9131
1584304	9656	1582449	9485	1580556	9309
1586002	9827	1584763	9647	1583079	9521



**Figure 1.** Validation results for solving the model in high dimensions by eliminating the penalty and transportation time in relation to costs.



**Figure 2.** Validation results of solving the model in large dimensions by eliminating penalty and transportation time constraints with respect to time.

The above graph shows the relative effect of reducing fines and transportation time on the objective function of time. Although this reduction is not as high as the cost, it is still tangible; therefore, the validity of the model can be confirmed by removing these two parameters. Figure 2.

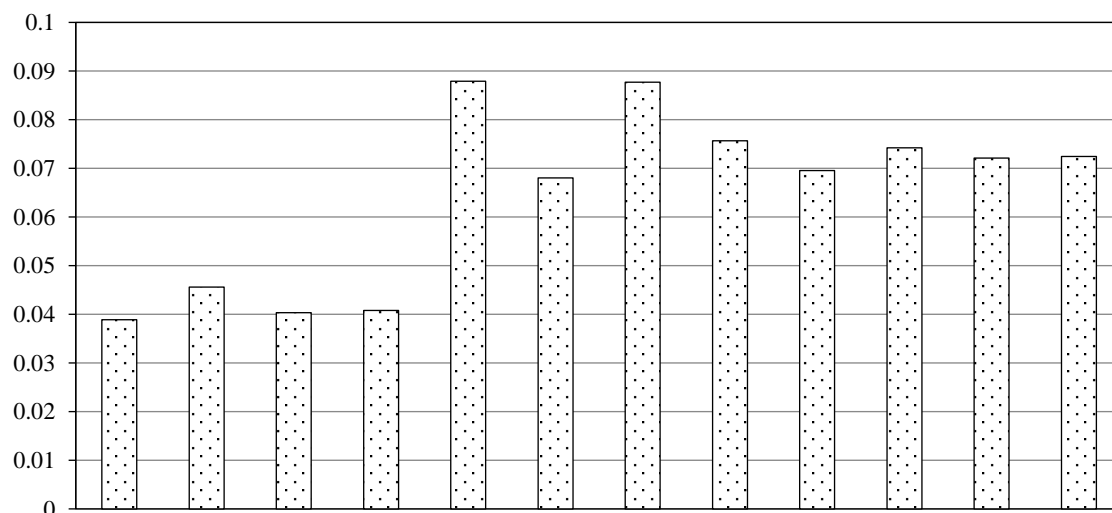
## DISCUSSION AND FINDINGS

This section presents a comparison and analysis of the findings. According to the results obtained from the effects of the different parameters, these effects were compared in the form of Table 3.

The most effective parameters for the cost of the entire system are the loading penalty of incoming containers and accumulation time, which together have an effect of approximately 8.5% on the cost. Therefore, they can increase the cost of the entire system by 8.5%, but the effect of the other parameters is much less Figure 3.

**Table 3.** Comparison of parameters affecting the cost.

	10%	20%	30%	40%	50%
Accumulation penalty	0.006673	0.016219	0.025261	0.031532	0.038864
Recovery penalty	0.010651	0.02295	0.031269	0.040707	0.045595
Inbound container shipping fine	0.009168	0.018127	0.025314	0.031992	0.040357
Outgoing container shipping fine	0.012104	0.02332	0.028982	0.035226	0.040784
Penalty for loading the incoming container	0.02457	0.047002	0.060238	0.075394	0.087887
Outbound container loading fine	0.013391	0.037338	0.050836	0.060498	0.068058
Accumulation time	0.021376	0.043661	0.061427	0.076764	0.087728
Recovery time	0.021622	0.038721	0.058463	0.068249	0.075663
Inbound container shipping time	0.02285	0.036392	0.049484	0.060844	0.069533
Outbound container shipping time	0.024447	0.038973	0.054363	0.064587	0.074242
Inbound container loading time	0.015233	0.02759	0.042864	0.054088	0.072094
Outbound container loading time	0.020516	0.039003	0.049936	0.061576	0.072453

**Figure 3.** Comparison of parameters affecting the cost.

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