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Designing Product Placement Strategy for Outbound Loading Process in C4 Container Trucks at PT XYZ

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Abstract

Distribution logistics efficiency is crucial in the fast-moving consumer goods (FMCG) industry, in which high production volumes, frequent shipments, and tight delivery schedules demand optimal container utilization. PT XYZ, a leading FMCG company, faces significant challenges in maximizing the loading efficiency of C4 container trucks during their outbound operations. The objectives of this study are to analyze the causes of the decline in Vehicle Space Optimization (VSO) and evaluate the impact of implementing a product placement strategy on cost ratio and shipment value. A review of logistics and container loading literature pointed out the importance of strategic arrangement in improving space efficiency and reducing transportation costs. This study used historical shipment data from December 2024 and product dimension data from PT XYZ to develop a linear programming model for achieving the most efficient loading configuration. The proposed layout was performed using EasyCargo simulation software to visualize its spatial performance. The results demonstrated that the optimized strategy increases VSO by 5.39%, reduces the cost ratio by 0.09%, and improves the value of goods in a single shipment. These findings revealed the effectiveness of mathematical modeling and simulation in improving outbound distribution performance. In addition, this study highlights the importance of data-driven in decision-making for warehouse and distribution planning. For FMCG companies, this strategy provides a practical technique to minimize operational costs, maximize truck capacity, and improve overall distribution efficiency. The implementation of this method may provide a competitive advantage and long-term cost savings for the company.

Keywords

Vehicle space optimization, linear programming, optimization, container loading, logistics efficiency.

1. Introduction

The fast-moving consumer goods (FMCG) industry operates under conditions of high sales volume, rapid product turnover, and relatively thin profit margins. This indicates that distribution is a critical aspect, with efficiency being a key determinant of long-term competitiveness and profitability (Shakur et al., 2024; Umbrex, 2025). In Indonesia, the FMCG industry is one of the largest sectors in Southeast Asia, with a market value of over USD 100 billion by 2023, and is projected to grow at a compound annual growth rate of around 7.6% until 2025 (Market Research Indonesia, 2025). This situation has resulted in demands on FMCG companies' logistics and transportation systems to actively implement supply chain optimization strategies, particularly through digitalization and maximizing container space utilization. It aims to reduce logistics costs, accelerate delivery times, and improve distribution reliability. Chauhan et al. (2023) pointed out that digital-based optimization of transportation and warehouse performance could have a significant positive impact on FMCG distribution performance, including increasing delivery speed and order fulfillment accuracy. In addition, prior works also stated that logistics optimization, especially related to warehouses and transportation, enables increasing the overall distribution efficiency of FMCG companies (Mokarrari et al., 2025; Pasupuleti et al., 2024).

Efficiency indicators in container loading are increasingly important in modern logistics operations, especially through the Container Loading Problem (CLP) and 3D Bin Packing approaches, which aim to maximize packing density and minimize empty space (Bortfeldt and Wäscher, 2013; Pisinger, 2002; Truong and Chien, 2024). % Vehicle Space Optimization (VSO) functions as a measure that shows the percentage of container utilization that can be used optimally to load goods or cargo (Romero-Olarte et al., 2025; SAP, 2025). Several heuristic algorithms with the aid of simulation software have been proven to be able to provide suggestions for cargo arrangements that can maximize the use of container capacity (Avcı et al., 2023; Cildoz et al., 2024; Erbayrak et al., 2021; Truong and Chien, 2024; Weerasinghe et al., 2024; Zhu et al., 2021). Optimizing container space with a high %VSO not only reduces underfill or overfill but also increases the efficiency of logistics costs per unit of goods and speeds up the overall loading and shipping process (Bortfeldt and Wäscher, 2013; Pisinger, 2002).

PT XYZ is a company operating in the FMCG sector. FMCG companies are essential in fulfilling consumer demands promptly and effectively. This industry is characterized by high production volumes, intensive distribution frequency, and a focus on operational efficiency to maintain competitiveness in the market (Jeshvaghani et al., 2023; Ugrinov et al., 2024). PT XYZ is committed to providing quality products to various Distribution Centers (DCs) with reliable and efficient logistics processes. However, in distribution operations, there are significant challenges in managing deliveries, especially in maximizing the utilization of space in container trucks. Shipping goods using container trucks plays a key role in PT XYZ's distribution chain. One metric used to measure delivery efficiency is %VSO, which is the percentage of space utilization in the transport vehicle. But in practice, %VSO is inconsistent, even with the same product quantity and type.

Figure 1 and Figure 2 show that the number of shipments and the average %VSO have decreased over the last five months, along with inconsistencies in the %VSO during the last two months, specifically November and December. The inefficient %VSO value can be caused by the strategy in managing container space. This inconsistent %VSO efficiency not only impacts the management of container car space but also affects shipping costs. As an FMCG company oriented towards efficiency and sustainability, PT XYZ needs to address this problem to maintain its competitive advantage. Thus, this study aims to develop a strategy for arranging product cardboard boxes in container cars using effective simulation techniques. This approach is expected to increase %VSO, optimize the use of shipping space, and simultaneously reduce the company's operational costs. This research is not only relevant to improving logistics efficiency at PT XYZ but also contributes to best practices in logistics management in the FMCG industry in general.

This study proposes a combined approach between a Linear Programming (LP) mathematical model and three-dimensional (3D) visual simulation as a practical solution to address the problem of inefficient space utilization in the container loading process at PT XYZ. By utilizing software such as Easy Cargo, the product arrangement resulting from LP optimization can be validated visually and realistically, allowing the company to evaluate and implement more accurate and applicable loading strategies in the field. This approach not only improves the %VSO as an indicator of how efficiently container space is utilized but also has a direct impact on the efficiency of distribution costs per unit of goods shipped. In addition, increasing consistency in the loading process also supports the principle of sustainable logistics by reducing the number of delivery trips, carbon emissions, and the use of logistics resources

(Budiyanto et al., 2021; Chen et al., 2024). Thus, the strategy proposed in this study provides a real contribution to increasing the operational competitiveness of FMCG companies in facing complex and dynamic distribution challenges. This study focuses on two problem formulations: (1) How can we overcome the decline in %VSO in C4 container cars at PT XYZ? and (2) How does implementing a product placement strategy affect the cost ratio and value of goods in the shipping process?

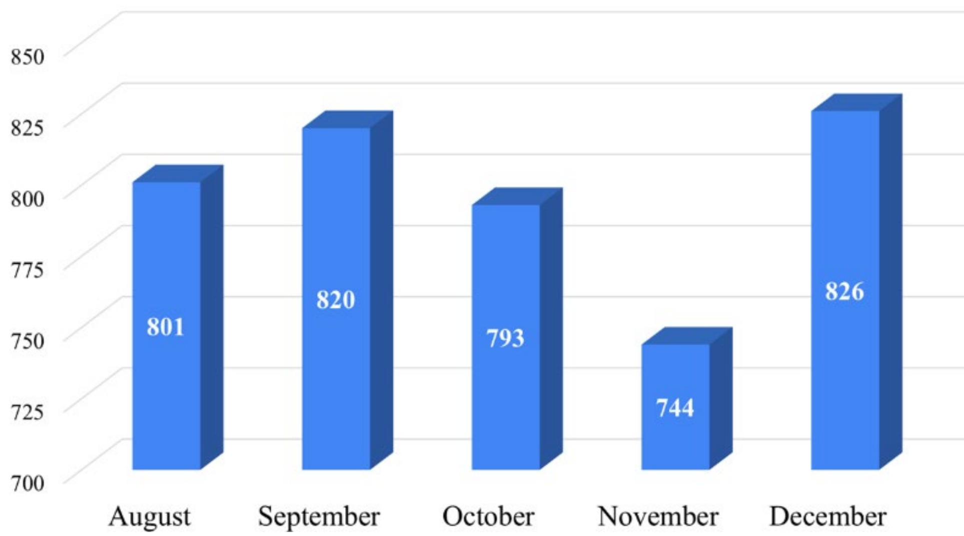

Figure 1. Data on the number of C4 container shipments for the period August – December 2024 at PT XYZ

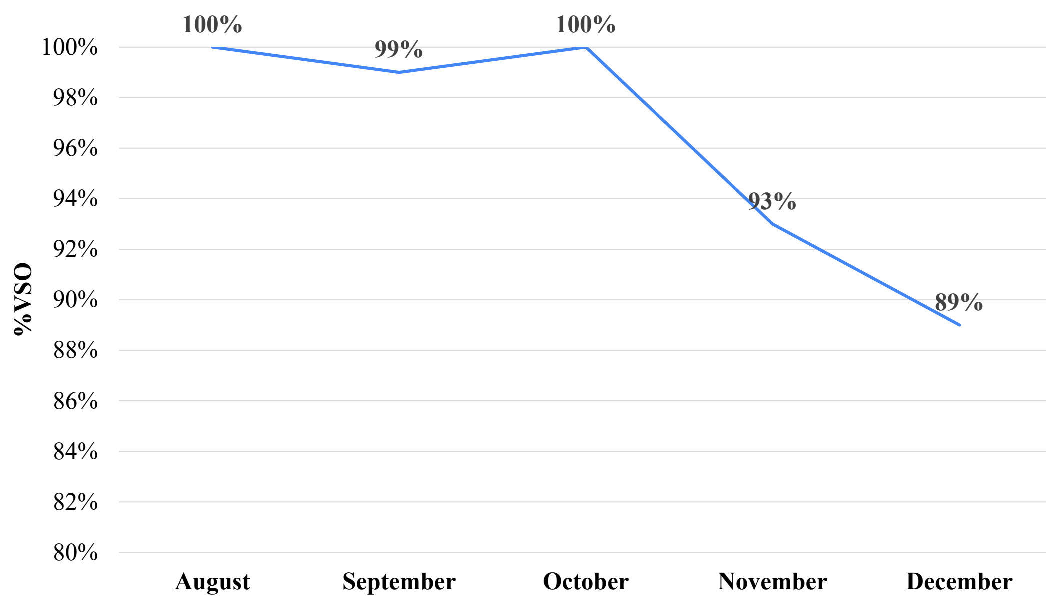

Figure 2. Average %VSO data for C4 container for the period August – December 2024 at PT XYZ

This study consists of five main sections. The first section is an introduction that explains the background, problem formulation, and the objectives and contributions of the study. The second section presents a literature review that discusses previous studies related to the container loading problem and space optimization using mathematical and simulation approaches. The third section contains an overview of the research methodology, including data collection, LP modeling, and the use of 3D simulation software. The fourth section presents the results and discussion related to the effectiveness of product placement strategies based on the %VSO indicator and shipping cost efficiency. Finally, the fifth section contains conclusions and recommendations from this study along with practical implications that can be applied in the scope of logistics management in the FMCG industry.

2. Literature Review

A container terminal is an intermodal interface that connects maritime transport modes, such as container ships, with land transport modes, such as trucks or trains. In addition to handling loading and unloading activities, this terminal also provides temporary storage facilities for containers awaiting their next journey (Zhang et al., 2003). Optimizing container loading is crucial for enhancing operational efficiency at the terminal (Bortfeldt and Wäscher, 2013; Pisinger, 2002).

The container loading problem (CLP) is the problem of how to arrange some rectangular boxes into a rectangular container of fixed size in an orthogonal (perpendicular) manner (Pisinger, 2002). According to Bortfeldt and Wäscher (2013), the container loading problem can be viewed as a geometric assignment challenge, where small three-dimensional objects (cargo) must be allocated into large three-dimensional rectangular (cubic) objects (containers) to optimize a certain objective function while adhering to two fundamental geometric feasibility criteria: 1) all small objects must be completely contained within the container, and 2) the small objects must not overlap each other. In general, the cargo can be of any shape, whether regular (such as rectangular, spherical, etc.) or irregular. However, the majority of previous studies related to container loading have stated that the cargo is rectangular.

Container loading is a critical activity in improving the operational efficiency of the supply chain. Poorly performed container loading activities can lead to excess container shipments and poor customer service. Therefore, the issue of container loading has been extensively studied in the operations research literature (Bortfeldt and Wäscher, 2013; Montes-Franco et al., 2025; Patil and Patil, 2016; Romero-Olarte et al., 2025; Weerasinghe et al., 2024). Optimal container loading aims to reduce shipping costs while increasing the stability and support of the load. Truong and Chien (2024) explained that container loading has a vital role in logistics and supply chain management as it directly impacts costs and delivery times, thus impacting the competitive advantage of companies in various industrial sectors.

Based on the objective function and constraints used, Pisinger (2002) divides container loading problems into several categories, namely:

a. *Packing strip*. This type of variation means the container has a fixed width and height, but its depth is assumed to be infinite. The goal is to arrange all the boxes so that the required depth is minimized. The strip packing problem is often applied in multi-drop shipping situations, where the load must be divided into several parts suitable for different shipping destinations.
b. *Knapsack loading*. Knapsack container loading means that each box has a certain profit value. The challenge lies in determining how much of a box can fit into a single container to optimize the overall profit. If the profit of a box is assumed to be equal to its volume, then this problem is equivalent to minimizing the wasted space inside the container.
c. *Bin-packing*. This type means that all containers have fixed dimensions, and all boxes must be packed into the fewest possible number of containers.
d. *Multi-container loading*. This problem closely resembles the bin-packing problem; however, the key difference is that the containers can have varying dimensions, and the objective is to choose a subset of these containers that minimizes shipping costs.

Several previous studies have tried to examine the problem of container loading at terminals (Cildoz et al., 2024; Erbayrak et al., 2021; Fan et al., 2022; Romero et al., 2023; Truong and Chien, 2024; Wu et al., 2010; Zhu et al., 2021). Erbayrak et al. (2021) extends the classic three-dimensional bin packing problem (3D-BPP) model by considering load balancing based on the concepts of orientation and stability simultaneously. This study introduces a new concept called "family unity," which aims to place items from one product group (e.g., originating from the same order and the same shipping destination) into one package. A multi-objective mixed integer programming approach is used to determine the optimal loading plan, with the aim of minimizing the number of bins used and the equilibrium deviation from the ideal barycenter, while maximizing the family unity ratio through a weighted objective function. Truong and Chien (2024) investigated the problem of container loading by developing a UNISON-based framework that integrates the merging spaces algorithm, a hybrid of swarm optimization and simplified genetic algorithm (SSO-

GA), and a multi-population co-evolution strategy to determine the loading sequence of goods to maximize space utilization and weight balance while meeting practical constraints.

Research by Cildoz et al. (2024) attempts to develop a combination of statistical and optimization methods implemented in software to assist decision-makers in selecting the most appropriate container for each component. This container optimization problem considers container transportation costs, component handling costs, and empty container return costs. For individual placement, the problem is broken down into two optimization sub-problems solved using heuristic and exact algorithms. The company's real transportation data and simulation results are used to inform a learning algorithm that estimates container load capacity for bulk transportation. Avcı et al. (2023) conducted research aimed at minimizing space in containers using various optimization methods such as the OSQP solver, knapsack algorithm, linear optimization, and genetic algorithm. Zhu et al. (2021) proposed a Data-Driven Tree Search (DDTS) algorithm to solve the 3D-BPP problem. The solution space with various complex constraints was explored using a tree search algorithm, and the search process was accelerated with the help of a convolutional neural network (CNN). This algorithm has been implemented in Huawei's logistics system and has successfully increased the loading ratio by 3%, potentially saving millions of dollars in logistics costs annually. Weerasinghe et al. (2024) stated that genetic algorithms, integer linear programming, and heuristics are the most widely used operational research techniques in container terminal optimization.

Heßler et al. (2025) studied the problem of air cargo loading in three-dimensional packaging (Three-Dimensional Variable Size Bin Packing Problem), with special bin shapes in the form of cuboidal and non-cuboidal Unit Load Devices (ULDs) using the Randomized Greedy Search approach. Montes-Franco et al. (2025) proposed a hybrid scheme to solve the container loading problem by integrating a mechanical model into the Reactive GRASP (Greedy Randomized Adaptive Search Procedure) metaheuristic algorithm. The mechanical model used dynamically analyzes the forces and accelerations acting on the cargo to predict the risk of loss of support, overturning, or critical velocity changes that could damage the cargo. In addition, the Reactive GRASP algorithm also considers dynamic stability indicators in each step of its repair.

3. Methods

This research was conducted in seven stages, namely (1) field observation, (2) determining the background of the research problem, (3) preliminary study, (4) collecting research data, (5) processing research data, (6) discussing and analyzing data, and (7) drawing conclusions and suggestions. The first stage is the field observation stage, which aims to conduct direct observations at the research location to gain an in-depth understanding of the conditions and situations in the field. This field study provides an overview of how outbound loading, especially for C4 container cars, works at PT XYZ. The second stage is determining the background of the research problem. At this stage, the background of the problem to be solved is identified and formulated. This background includes operational conditions obtained from the results of the observations made. The third stage is a preliminary study to explore materials relevant to the research. The materials studied include linear programming to determine the optimal arrangement of cardboard boxes in cars, simulations using Easy Cargo, and also studying the cost-benefit analysis method to calculate costs after improvements are made. The fourth stage is collecting research data. The data needed to support analysis and problem solving are collected, including 1) data on maintaining all product boxes at PT XYZ, 2) data on % vehicle space optimization in December 2024, and 3) historical data on shipments in December 2024.

Next, in the fifth stage, the research data is processed. The collected data are processed using relevant methods. Data processing includes 1) creating a flow diagram that describes the process before and after system implementation, 2) creating a simulation with Easy Cargo based on the results of linear programming, and 3) analyzing the results and calculating profits after implementing the new system. The sixth stage is data discussion and analysis. This stage includes an in-depth discussion and analysis of the processed data. The findings from outbound data based on field observations on loading the C4 container are discussed. The problem is also analyzed, the implementation of the new system is calculated, and it is analyzed further by simulating the Easy Cargo software. The profits obtained by PT XYZ are also analyzed. The final stage is drawing conclusions and suggestions. The conclusions of the research are compiled based on the results of the discussion and data analysis. Conclusions are presented to answer the problem formulation that has been previously determined.

4. Results and Discussion

PT XYZ is a company engaged in the sanitary napkin, baby diaper, and medical device industries. From August to December 2024, PT XYZ made various product deliveries using C4 container trucks, as shown in Figure 1. The data shows the number of product deliveries per month as follows: 801 deliveries in August, 820 deliveries in September, 793 deliveries in October, 744 deliveries in November, and 826 deliveries in December.

Furthermore, based on the number of deliveries, the %VSO data for each month is recorded. The effectiveness of filling the space in C4 container trucks, as measured by the %VSO percentage, as shown in Figure 2, is an important indicator for PT XYZ. Figure 2 shows fluctuations in the %VSO from August to December 2024. In August and October, the %VSO value reached an optimal level of 100%. However, there was a slight decrease in September to 99%. After October, the %VSO began to decline significantly, reaching 93% in November and reaching its lowest point of 89% in December. This decline indicates that shipments are still suboptimal.

In this study, several data were used to analyze the problem of loading containers at PT XYZ, one of which was the data on maintaining all product boxes as presented in Table 1. In the process of shipping and distributing products, PT XYZ applied a system of arranging goods based on categories that include product ID, storage conditions, and arrangement methods in containers. This strategy aimed to optimize the use of space efficiently, minimize the potential for product damage during transit, and increase load stability so that distribution can run smoothly. The products shipped include various categories, with each product having different packaging characteristics. Thus, the container's arrangement method considers the box's maximum capacity and the correct horizontal and vertical arrangement.

Table 1. Data to maintain the dimensions of PT XYZ product cardboard

Product ID	P (unit: mm)	L (mm)	T (mm)	BOX - VOL (CD3)
50047	380	305	325	37.67
50048	425	265	365	41.11
50050	450	295	325	43.14
1050051-1	445	315	155	21.73
1050051-2	445	315	205	28.74
50052	380	305	325	37.67
50053	430	275	375	44.34
50055	420	295	345	42.75
1050056	495	315	235	36.64
50057	405	295	295	35.25
50058	445	285	405	51.36
50060	445	295	355	46.60
50063	445	295	395	51.85
50065	435	315	380	52.07
50067	445	305	334	45.33
50068	445	305	345	46.83
50121	445	295	320	42.01
1050046-1	445	315	155	21.73
1050046-2	445	315	205	28.74
50014	325	285	225	20.84
50017	347	238	325	26.84
50018	347	350	240	29.15
50034	385	235	265	23.98
50035	385	235	265	23.98
50235	455	315	285	40.85
50236	425	195	295	24.45
50237	425	195	295	24.45
60228	375	230	249	21.48
60229	325	282	225	20.62
60265	415	375	250	38.91

60611	435	220	270	25.84
60613	375	195	270	19.74
61517	375	305	325	37.17
61520	385	233	265	23.77
61521	368	230	290	24.55
61522	450	295	200	26.55
62149	348	240	335	27.98
62150	350	240	330	27.72
62704	385	235	305	27.59
62705	395	185	300	21.92
62706	395	185	330	24.11
17002548	375	244	370	33.86
50122	280	215	205	12.34
50123	365	243	165	14.63
50199	280	215	205	12.34
50200	365	243	165	14.63
1150056-1	495	325	230	37.00
1150056-2	495	325	275	44.24
1150051	445	325	195	28.20
1150046	445	325	195	28.20

In addition to these data, several other data were also collected to support this research, one of which was the data on maintaining the size of the C4 Car container of PT XYZ, as shown in Table 2. The dimensions of the C4 Car container of PT XYZ were length, width, and height, respectively, namely 12,110; 2,350; and 2,650 mm. In addition to these data, shipping data on the value of goods and shipping costs for December 2024 were in Table 2.

Table 2. Shipping data of goods value and shipping costs December 2024

Shipment	Goods Value	Shipping Costs
1	201,697,998	1,610,000
2	39,672,570	5,290,000
3	178,644,816	1,552,500
4	173,062,320	906,600
5	212,120,034	3,335,000
6	171,349,650	3,640,000
7	175,211,190	1,034,000
8	225,739,632	1,135,200
9	147,406,080	1,251,400
10	86,564,100	926,000
11	120,190,170	2,875,000
12	250,209,792	1,265,000
13	217,833,570	1,265,000
14	145,696,500	1,265,000
15	347,150,688	1,921,000
16	221,416,944	2,415,000

Research was conducted to overcome this problem, in which several scenarios of arranging goods were analyzed and presented in Table 3. The scenario consisted of four conditions: The first condition was that Length was P, Width was L, and Height was T. The second condition was that length was L, width was T, and height was P. The third condition was that length was P, width was T, and height was L. The fourth condition was that length was T, width was L, and height was P. These scenarios were then analyzed using the LP model.

Table 3. Scenario for preparing product boxes for PT XYZ

Condition	Dimension Scenarios		
	Length	Width	Height
1	P	L	T
2	L	T	P
3	P	T	L
4	T	L	P

Condition 1 products were those that were stacked in a straight manner to maintain packaging stability during transit. These products tend to have a more rigid shape and therefore require more orderly placement in the container to avoid damage due to pressure. Some examples of products in this category include 50047, 50048, 50050, 50057, and 50058, as well as several variants of 61517, 62149, and 62150. These products have a straight arrangement, meaning that they are placed in a vertical position without rotation to prevent packaging deformation during transit.

Meanwhile, products classified under condition 2 were those that feature larger or more flexible sizes, enabling a combination of transverse and straight stacking to maximize space in the container. Some examples of products in this category were 50052, 50053, 50055, 50065, 60613, 50232, and 50233. These products have a mixed arrangement; that is, some were placed in a straight position to maintain stability, while others were placed transversely to fill spaces between stacks of other items.

Furthermore, products classified as condition 3 required a more complex stacking method due to their flexible packaging and the need for maximum space optimization. The stacking of these products generally used more transverse positions than straight to ensure more even load distribution and reduced spaces inside the container. Some products in this category were 1050051-1, 1050051-2, 50067, 50068, 60265, 62704, 62705, and 62706. These products have more transverse positions; that is, they were arranged in a horizontal position to optimize space in the container and avoid empty spaces that can cause the load to shift during transit.

Based on observations, PT XYZ applies a very strategic product stacking method by considering the characteristics of the packaging and distribution needs. With the applied method, products with condition 1 are stacked straight to maintain stability, products with condition 2 are stacked with a combination of transverse and straight for flexibility in space usage, and products with condition 3 require a more complex stacking method with more transverse positions to avoid empty space in the container. With this system, PT XYZ can ensure that shipping runs more efficiently, increase %VSO, and reduce the risk of product damage during distribution. This strategy supports logistical efficiency and ensures that each product arrives at its destination in the best condition, without experiencing deformation or damage due to suboptimal stacking.

This study conducted an in-depth analysis of the cardboard stacking process during the shipping process to ensure that product demand can be optimally met in a more efficient manner. One approach used was to sample a previous shipment to demonstrate that the LP method could provide better results in terms of container space utilization. We chose a single shipment as a sample to illustrate the efficiency of the previously used cardboard stacking method and pinpoint any shortcomings in the current shipping system.

The best cardboard arrangement conditions were determined based on the results of these conditions, with one condition based on the smallest difference shown in Table 4.

Table 4. Linear programming results for the final condition of PT XYZ's products

Product ID	Max Box	Condition	Arrangement	Stacking	Length	Width	Height	Volume
50047	1864	1	Transversely 2 Straight 5	8	380	305	325	37.67
50048	1780	3	Transversely 2 Straight 4	10	425	365	265	41.11
50050	1640	1	Transversely 5 Straight 0	8	450	295	325	43.14
1050051-1	3400	1	Transversely 1 Straight 6	17	445	315	155	21.73
1050051-2	2456	3	Transversely 2 Straight 7	8	445	205	315	28.74
50052	1864	1	Transversely 2 Straight 5	8	380	305	325	37.67
50053	1632	2	Transversely 3 Straight 4	6	275	375	430	44.34
50055	1650	2	Transversely 2 Straight 5	6	295	345	420	42.75
1050056	1936	1	Transversely 4 Straight 1	11	495	315	235	36.64
50057	1872	1	Transversely 5 Straight 1	8	405	295	295	35.25

50058	1332	1	Transversely 4 Straight 2	6	445	285	405	51.36
50060	1435	1	Transversely 5 Straight 0	7	445	295	355	46.60
50063	1230	1	Transversely 5 Straight 0	6	445	295	395	51.85
50065	1386	2	Transversely 5 Straight 2	6	315	380	435	52.07
50067	1512	3	Transversely 0, Straight 7	8	445	334	305	45.33
50068	1424	3	Transversely 2 Straight 4	8	445	345	305	46.83
50121	1640	1	Transversely 5 Straight 0	8	445	295	320	42.01
1050046-1	3400	1	Transversely 1 Straight 6	17	445	315	155	21.73
1050046-2	2456	3	Transversely 2 Straight 7	8	445	205	315	28.74
50014	3474	3	Transversely 1 Straight 9	9	325	225	285	20.84
50017	2717	3	Transversely 3 Straight 4	11	347	325	238	26.84
50018	2352	3	Transversely 4 Straight 4	7	347	240	350	29.15
50034	3100	1	Transversely 0, Straight 10	10	385	235	265	23.98
50035	3100	1	Transversely 0, Straight 10	10	385	235	265	23.98
50235	1746	1	Transversely 1 Straight 6	9	455	315	285	40.85
50236	2964	2	Transversely 6 Straight 4	6	195	295	425	24.45
50237	2964	2	Transversely 6 Straight 4	6	195	295	425	24.45
60228	3416	2	Transversely 8 Straight 2	7	230	249	375	21.48
60229	3474	3	Transversely 1 Straight 9	9	325	225	282	20.62
60265	1890	3	Transversely 2 Straight 6	7	415	250	375	38.91
60611	2838	2	Transversely 7 Straight 3	6	220	270	435	25.84
60613	3696	2	Transversely 12 Straight 0	7	195	270	375	19.74
61517	1960	1	Transversely 3 Straight 4	8	375	305	325	37.17
61520	3100	1	Transversely 0, Straight 10	10	385	233	265	23.77
61521	2952	1	Transversely 2 Straight 7	9	368	230	290	24.55
61522	2665	1	Transversely 5 Straight 0	13	450	295	200	26.55
62149	2618	3	Transversely 0, Straight 7	11	348	335	240	27.98
62150	2672	1	Transversely 6 Straight 1	8	350	240	330	27.72
62704	2574	3	Transversely 6 Straight 0	11	385	305	235	27.59
62705	3220	3	Transversely 2 Straight 5	14	395	300	185	21.92
62706	3080	1	Transversely 5 Straight 2	8	395	185	330	24.11
17002548	2163	2	Transversely 2 Straight 5	7	244	370	375	33.86
50122	5928	3	Transversely 4 Straight 6	12	280	205	215	12.34
50123	4976	1	Transversely 5 Straight 2	16	365	243	165	14.63
50199	5928	3	Transversely 4 Straight 6	12	280	205	215	12.34
50200	4976	1	Transversely 5 Straight 2	16	365	243	165	14.63
1150056-1	1952	3	Transversely 1 Straight 8	8	495	230	325	37.00
1150056-2	1632	3	Transversely 3 Straight 3	8	495	275	325	44.24
1150051	2592	3	Transversely 0, Straight 12	8	445	195	325	28.20
1150046	2592	3	Transversely 0, Straight 12	8	445	195	325	28.20

Furthermore, the results obtained from the LP were tested using Easy Cargo simulation to visualize 3D and prove that the results can provide an increase in %VSO, where we obtained a sample shipment and tried to apply it with the arrangement that had been obtained in linear programming. Table 5 presented the data on DC requests or orders sent to PT XYZ for the shipment.

Table 5's demand data revealed varying demand levels for several products. Product ID 50055 has a demand of 462 units, while product ID 50063 has a demand of 120 units. Other products, such as 50065, require 210 units; 50067, 280 units; and 50236 has a demand of 300 units. Furthermore, product ID 60613 has the highest demand at 504 units, while 62704 has the lowest demand at 60 units. These differences in demand indicated the need for a more optimal scheduling strategy to maximize delivery capacity.

However, after evaluating the shipping data, it was discovered that the number of successfully shipped units did not fully meet existing demand, primarily due to limited container space, which prevented some products from being entirely shipped. This factor was a major obstacle in previous shipments, where there was still empty space in the containers that could have been optimized to accommodate more products. The imbalance between demand and successfully shipped quantities necessitates a more systematic approach to enhance the efficiency of space utilization.

Table 5. Request data for one of PT XYZ's shipments

Product	Demand
50055	462
50063	120
50065	210
50067	280
50236	300
60613	504
62704	60

To demonstrate the LP method's ability to address this issue, mathematical calculations were performed, taking into account container capacity, box dimensions, and the number of product units to be shipped. These calculations aimed to determine a more optimal stacking solution to more effectively utilize previously unused capacity. Using this method, a new stacking pattern was obtained that allowed each box to be placed in its most efficient position, allowing previously unshipped quantities of product to be accommodated in a single additional shipment.

After developing this optimization model, a simulation using EasyCargo (Figure 3) was conducted to verify the effectiveness of the calculated strategy. This simulation was conducted by comparing the cardboard stacking pattern from the previous shipment with the optimized stacking results using LP. The simulation results showed that by applying this optimization method, all unmet demand from the previous shipment could be delivered in a single additional shipment, without the need for additional trips or the use of additional vehicles.

Furthermore, the %VSO increased from 87% (Table 6) to 93% (Figure 4), indicating more effective use of container space. This demonstrates that the use of the LP method not only helps meet previously undeliverable demand but also improves overall shipping efficiency. With an increased %VSO, companies can reduce the number of shipments required, ultimately reducing operational costs, increasing delivery speeds, and optimizing the use of logistics resources.

Table 6. Historical data of one of PT XYZ's shipments in December

Product	Number of shipments	Amount of difference	%VSO
50055	462	0	87%
50063	120	0	
50065	210	0	
50067	280	0	
50236	300	0	
60613	455	49	
62704	0	60	

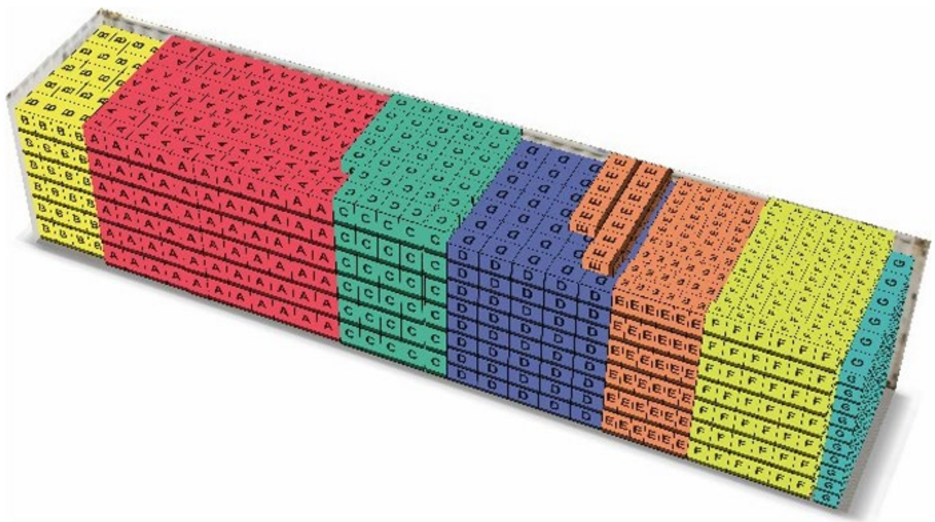

Figure 3. 3D visualization of Easy Cargo shipment of C4 container at PT XYZ

Custom Container 20' (12,110 mm x 2,350 mm x 2,650 mm)
Total weight 1,966 kg (20%)
Total volume 69.82 m^3 (93 %)
Shift to right 0 m
Shift in length 0 m
Free meters 0.137 m

	Description	Pieces	Length	Width (cm)	Height	Total Weight (kg)
Group No. 1						
A	A	492	29.5	34.5	42.0	492.0
B	B	120	44.5	29.5	39.5	120.0
C	C	210	31.5	38.0	43.5	210.0
D	D	280	44.5	33.4	30.5	280.0
E	E	300	19.5	29.5	42.5	300.0
F	F	504	19.5	27.0	37.5	504.0
G	G	60	38.5	30.5	23.5	60.0

Figure 4. Detail data visualisasi 3D Easy Cargo shipment of C4 container at PT XYZ

Sampling from a previous shipment demonstrated LP's ability to address the challenges of inefficient space utilization. This method allowed the company to reorganize product placement within containers to optimize the product layout, minimize space, and improve cargo stability during transit (Hu et al., 2024; Romero-Olarte et al., 2025). Furthermore, these results indicated that the company can apply this optimization strategy to future shipments to enhance overall distribution efficiency.

Based on Table 7 and Figure 4, it can be seen that the combination of LP and EasyCargo simulations provided a better solution for arranging cardboard boxes inside containers. Implementing a more efficient arrangement optimizes container capacity, enabling the shipment of each requested product unit without any obstacles. Therefore, the implementation of this method was highly recommended as a standard strategy in PT XYZ's delivery system to ensure that every request can be optimally fulfilled by utilizing the available space capacity inside the container. Furthermore, the simulation results were able to meet planned demand and increase the %VSO value from 87% to 93%, a 5.86%

increase. Therefore, a recalculation was performed using 16 shipments that occurred in December to determine whether the VSO structure had any impact. Table 7 displays the shipment data.

This study evaluated the effectiveness of a shipping optimization strategy by examining its impact on the cost ratio and value of goods shipped. The analyzed data included 16 shipments, each with a cost ratio percentage before and after the optimization strategy was implemented, as well as the resulting cost differences. The calculations revealed that the strategy successfully reduced the average cost ratio by 0.09% while simultaneously increasing the value of goods shipped by Rp 9,820,485, as presented in Table 8.

The overall difference revealed a 0.09% reduction in the average cost ratio, signifying that the optimization technique effectively enhanced shipping efficiency. This decrease in the cost ratio means lower costs per unit of goods shipped, ultimately reducing overall logistics expenses. This has a direct impact on distribution efficiency, particularly in optimizing operational costs without sacrificing shipping volume.

In addition to lowering the cost ratio, implementing this strategy also increased the value of goods shipped in each shipment, with a total increase of Rp 9,820,485. This suggested that optimizing shipping capacity can enable the shipment of more products per trip without significantly raising costs. The shipment with the largest increase in value was shipment 15, which saw an increase in value of goods shipped to Rp 18,719,164, while other shipments also experienced significant increases in value.
Overall, the results of this study indicated that the implemented optimization strategy has been proven to improve shipping efficiency, both in terms of costs and the volume of goods shipped. With a 0.09% decrease in the average cost ratio and an increase in the value of goods shipped by up to IDR 9.8 million, this strategy can be used as a standard in distribution systems to ensure that each shipment is carried out more efficiently and reduce wasteful logistics costs.

Table 7. Shipping data for 16 shipments after using the proposed compilation strategy

Shipment	**%Before**	**%After**	**%Difference**
1	96	100	3.50
2	90	96	6.15
3	100	100	0.00
4	83	92	9.23
5	91	96	5.94
6	86	92	5.96
7	93	95	1.31
8	94	97	2.94
9	91	99	7.71
10	84	88	3.20
11	85	89	3.75
12	86	95	9.31
13	85	90	4.97
14	85	94	8.40
15	86	92	5.23
16	82	90	8.69
Mean		**5.39**	

Table 8. Results of the % cost ratio and value of goods for 16 shipments
after using the proposed preparation strategy

Shipment	**% Cost Ratio Before**	**% Cost Ratio After**	**% Cost Ratio Difference**	**Shipping Cost Difference**
1	0.80	0.76	0.04	10,876,020
2	13.33	12.65	0.68	2,139,236
3	0.87	0.82	0.04	9,632,940
4	0.52	0.50	0.03	9,331,919
5	1.57	1.49	0.08	11,438,000

6	2.12	2.02	0.11	9,239,567
7	0.59	0.56	0.03	9,447,791
8	0.50	0.48	0.03	12,172,400
9	0.85	0.81	0.04	7,948,475
10	1.07	1.01	0.05	4,667,735
11	2.39	2.27	0.12	6,480,931
12	0.51	0.48	0.03	13,491,888
13	0.58	0.55	0.03	11,746,087
14	0.87	0.82	0.04	7,856,291
15	0.55	0.53	0.03	18,719,164
16	1.09	1.03	0.06	11,939,311
Mean			**0.09**	**9,820,485**

With an effective container loading strategy, companies can increase shipping effectiveness and minimize the number of inefficient trips, resulting in lower operational costs and faster and more accurate distribution (Chauhan et al., 2023; Shakur et al., 2024). PT XYZ anticipates that the implementation of this optimal arrangement strategy will serve as a sustainable solution to enhance distribution performance and supply chain efficiency. The implementation of this strategy also has a positive impact on reducing the company's operational costs because, with the same amount of cost, the company can deliver more products to distribution destinations. In other words, this efficiency allows the company to increase delivery capacity without the need for additional vehicles or trips, thereby reducing overall transportation costs. Considering these results, the implemented optimization strategy can be a sustainable solution in the company's distribution system. In addition to increasing the effectiveness of vehicle capacity utilization, this strategy also contributes to reduced logistics costs, increased supply chain efficiency, and faster and more accurate product delivery. Therefore, this approach can be applied more broadly in PT XYZ's logistics system to achieve optimal and sustainable distribution efficiency.

5. Conclusion

This study aims to solve the problem of inefficiency in container space utilization in the product distribution process at PT XYZ by using a combined method of linear programming mathematical models and 3D visual simulations using Easy Cargo. The results of the study indicate that the use of both methods can increase product placement efficiency, optimize container space, and generate distribution cost savings per unit of goods. The application of the LP model allows the company to systematically and optimally arrange the loading sequence of cardboard boxes based on product dimension and volume data. This model is then visually validated through 3D simulations in Easy Cargo, which shows a significant increase in %VSO. Before the improvement, the %VSO value in December 2024 was 87%, but after optimization with this approach, it increased to 93%. In addition, the application of product placement strategies in C4 Container cars can increase the average %VSO by 5.39% in shipments. The implementation of product placement strategies in C4 Container cars can decrease the average shipping cost ratio by 0.09% and increase the value of goods in shipments by 9.8 million. Further research is expected to develop a more optimal product placement strategy. To effectively implement this strategy, PT XYZ is advised to provide regular training to loading officers and loading managers. Furthermore, periodic inspections of the strategy's implementation process are necessary to ensure the system is running smoothly and consistently.

Authors' contributions

Fitriadi: Conceptualization, investigation, writing–original draft, data collection, data curation, formal analysis, software, and visualization. Hwi-Chie Ho: writing – review and editing, validation, methodology, supervision, and funding acquisition. Amir Tjolleng: writing – review and editing, project administration.

Data availability statement

The data that supports the findings of this study are available in this article.

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Biographies

Fitriadi is a final-year undergraduate student at Bina Nusantara University Indonesia, majoring in Industrial Engineering with professional experience in the Fast-Moving Consumer Goods (FMCG) sector. He is currently undergoing an internship program at one of Indonesia's largest FMCG companies, where he contributes to various strategic projects within the logistics and distribution division. In his role as a Logistics Excellence Intern, he is involved in warehouse system analysis, inbound-outbound process optimization, and the digitalization of inventory processes using platforms such as AppSheet and Google Apps Script. He also actively participates in developing strategies for improving truck loading efficiency aimed at increasing Volume Space Optimization (VSO) and reducing cost ratios in distribution. Additionally, he has been actively involved in digitalization and improvement projects within the warehouse production sector. His engineering background, passion for automation, and hands-on industrial experience drive him to deliver innovative solutions in logistics, distribution, and sustainable industrial systems. Outside of his academic and professional responsibilities, he is actively involved in campus organizations. He previously served as Project Manager in the Bina Nusantara Industrial Engineering Student Association (HIMTRI), where he organized various training programs and workshops to enhance students' soft and hard skills. He also served as a staff member in the same organization, focusing on the development of student competencies in industrial engineering through seminars, technical workshops, and competitions. His dedication to continuous learning and development reflects his drive to contribute meaningfully to the future of industrial engineering and supply chain innovation.

Hwi-Chie Ho is a professional engineer and Associate Professor of Industrial Engineering at Bina Nusantara University (BINUS), Indonesia. Formerly Dean of the Faculty of Engineering and BASE (2009–2022), her expertise lies in ergonomics and industrial psychology. A committed IISE member and faculty advisor, she led BINUS Student Chapter #716 to win the Gold Award (2012–2023) and received multiple regional awards as a faculty advisor. As an IEOM Fellow and frequent speaker, she actively contributes to global academic forums. Previously CEO of Audi & Volkswagen Indonesia, she was named one of *SWA Magazine*'s Top 40 Executives in Indonesia in 2002.

Amir Tjolleng is an Assistant Professor of Industrial Engineering at BINUS University Jakarta. He received the BS degree in mathematics from the Sam Ratulangi University Manado, Indonesia, in 2013, and the MS and PhD in industrial engineering from the University of Ulsan, South Korea, in 2017 and 2021, respectively. His research interests include human factors and ergonomics, human performance and workload evaluation, and data analysis. His work often explores the integration of physiological signal processing and artificial intelligence to improve human performance, health and safety, as well as efficiency in human-centered systems. He also received several academic awards, including the Best Teaching Award in the Industrial Engineering Study Program at BINUS University for the 2022/2023 academic year. He also received the Best Paper Award at the Autumn Conference of the Ergonomics Society of Korea (ESK) in 2018 and the Best Paper Award in the Master Thesis Competition at the Fall Conference of the Korean Institute of Industrial Engineers (KIIE) in 2016. He is also a member of the Perhimpunan Ergonomi Indonesia (Indonesian Ergonomics Society).