

Simulation Optimization of Truck Queue Loading Process Using Discrete Simulation Approach Using Promodel Software at PT. XYZ

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Simulation Optimization of Truck Queue Loading Process Using Discrete Simulation Approach Using Promodel Software at PT. XYZ

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ABSTRACT

Warehouses have an important role for companies, including PT. XYZ located in Karawang. This research aims to optimize truck queues in the loading and loading process at PT. XYZ uses a discrete simulation approach with ProModel software. The problem of long truck queues and high delivery order (DO) waiting times disrupted the operational efficiency of distribution facilities. In this study, 3 simulation scenarios were tested to evaluate the impact of adding loading docks on throughput, waiting time, and resource usage by removing the Delivery Order (DO) waiting time. The data collected includes loading and loading process time, namely truck arrival data, warehouse information data, transport truck information data, and product information data implemented using ProModel software and then validated through replication tests and validity tests using the t-test method. The simulation results show that using scenario 1, the addition of one loading dock increases throughput by 45% and reduces the average wait time from 18 minutes to 9.3 minutes per truck. In addition, the use of resources becomes more optimal, increasing overall productivity. With these results, the study concludes that the addition of loading dock is an effective solution to overcome bottlenecks in the loading process at PT. XYZ, which can be implemented to improve operational efficiency.



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1. Introduction

A warehouse is a place used to store goods in large quantities in anticipation of fluctuating consumer demand. In addition, warehouses also function as temporary storage for finished goods, semi-finished goods, raw materials, spare parts, equipment, and a place to add value to an item, or any goods that support the activities of a company (Zhang et al., 2017). Good warehouse management can reduce losses and costs, as well as improve service speed and operational efficiency. Each warehouse is designed to meet the specific needs of a company's supply chain activities, so its operations can differ from one business to another. In general, the warehouse process includes receiving, storing, ordering, sorting, adding value, and shipping (Rushton, A., Croucher, P., and Baker, 2014).

PT. XYZ is a company that produces culinary products with typical Indonesian flavors and has a warehouse to store these items. However, there are problems that hinder supply chain activities, especially in the process of loading goods in the warehouse loading dock. PT. XYZ uses four types of trucks for distribution, namely CDD, Engkel, Container, and Tronton load trucks, with three active loading docks. The average time of truck service tends to be long, leading to the next truck queue, which can result in cost losses and decreased customer satisfaction due to customer loss.

The research data used is data on the fleet loading time cycle to provide an overview of the performance of the loading process of each fleet. This data presents about the average load time for

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each fleet or vehicle type, which can help identify the most efficient fleet and which need improvement. This data also shows variations in loading process times between fleets or vehicle types, which can reveal differences in loading process efficiency. This analysis makes it possible to evaluate the loading performance of the fleet based on the type of goods being transported and identify areas where efficiency improvements can be made, including the delay time that occurs in the DO process during loading activities.

This research aims to minimize truck queues in the loading process at the PT. XYZ by decreasing the average time in system by increasing the number of loading docks. A comparison of the performance of the existing system with the proposed scenario shows that the addition of loading docks reduces truck waiting time from an average of 18 minutes to 9.3 minutes, thereby increasing throughput from 22 trucks per day to 32 trucks per day. Operational efficiency has also improved with the reduction of bottlenecks in the loading dock from an average of 114 minutes to 104 minutes. This research is divided into I: introduction which contains problem identification, research methodology, data processing using ProModel 10.6.36, and conclusions based on the results of the research.

2. Methods

The following is a picture of the flow chart in this study:

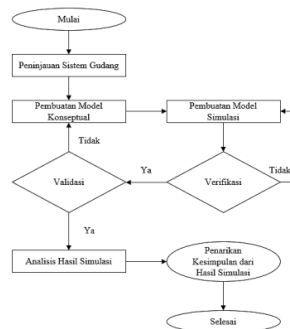


Fig. 1 Research Flow Diagram

The simulation research on truck queue optimization in the loading and loading process using a discrete simulation method with ProModel software aims to improve efficiency in truck queue management during the loading process. The initial step involves an in-depth understanding of the workflow and the factors that affect performance, such as loading capacity and runtime. Through modeling with ProModel, elements such as trucks, loading areas, and process times are integrated into the simulation model. This type of research can be categorized as quantitative research, which involves collecting numerical data that can be statistically analyzed to answer research questions and test hypotheses. In this study, the data collected includes truck arrival data, warehouse information data, transport truck information data, and product information data.

Warehousing not only includes goods storage activities, but also the handling of goods starting from receipt and recording, storage, selection, labeling, to delivery of goods (Warman, 2010:75). Through good warehousing management, transportation distances in distributing goods can be shortened and the frequency of item picking and delivery to customers can be increased. Warehouses are needed in the process of coordinating the distribution of goods due to the imbalance between the supply and demand processes, which encourages the emergence of inventory or inventory that requires temporary storage space. Supply chain management is a series of activities that include planning, managing, and activating products, with an efficient-based cost strategy to increase profits (Jebarus, 2001). The use of information technology, such as software, is indispensable to manage this process.

Queue theory discusses the mathematical study of queues, which occurs when the arrival of customers exceeds the capacity of the service. Simulation is the modeling of real systems based on events that take place over time (R.C. Harrell, 2004). Discrete refers to data or variables that can only take a finite specific value, as opposed to a continuous one. Discrete simulations model a system that evolves according to changes in certain variables under certain conditions, and is suitable for problems with specific time stages. The advantage of discrete simulation is its ability to model wait times that are not clearly known in a system. Simulation-optimization seeks and makes decisions from the results of experiments by verifying, validating, and analyzing data to find optimal conditions (Suprianto et al., 2018).

ProModel is a software used to simulate and analyze production systems of various types and sizes. The software allows the creation of realistic simulation models of the loading and unloading process of trucks, including all variables such as waiting time, loading time, loading capacity, and truck arrival patterns. ProModel provides the flexibility to easily add dock doors to the simulation model, allowing researchers to evaluate the impact of adding the number of loading docks on throughput and operational efficiency. ProModel also supports optimization and sensitivity analysis to examine how parameter changes affect simulation results. Validation and verification of simulation models is important to ensure the accuracy of the model by comparing the simulation results with empirical data or field observations.

3. Results and Discussion

Optimization of the loading and unloading process is a crucial aspect in logistics management, especially for large companies such as PT. XYZ which faces the challenges of truck queuing and dock loading efficiency. This research focuses on data collection and analysis to understand existing obstacles and find optimal solutions through discrete simulations using ProModel software. Here's the discussion.

Table 1 Summary Loading Time of Transporter Fleet with 4 Loading Docks

Work Element		Declare (Detik)			
		CDD	Ankle	Tronton	Container
Summary	Total Time (In Seconds)	4581	7955	9568	5164
	Total Time (In Minutes)	76	133	159	86
	Total Time (In Hours)	1,3	2,2	2,7	1,4
	FG Withdrawal Time from Production (In Hours)	2,0	2,0	2,0	2,0
	FG Withdrawal Time from FS (In Hours)	0,7	0,7	0,7	0,7
	Loading Dock	3	3	3	3
	Available Time (In Hours)	11,3	11,3	11,3	11,3
	Maximum Number per Fleet Type	27	15	13	24
	Loading Portion	48%	18%	18%	16%
	Maximum Amount per Fleet Type according to Portion	13	3	2	4
	Hood. Per day		7		Car/day
	Caps per 3 LD		22		Car/day

Source: Company Data

The results and discussion sections are one of the challenging sections in your article. The purpose of the Results section is to present the key results of your research. Results and discussions can either be combined into one section or organized as separate sections depending on the journal's requirements to which you are submitting your research paper. Use subsections and subheadings to improve readability and clarity. Number all tables and figures with descriptive titles. Present your results as figures and tables and point the reader to relevant items while discussing the results. This section should highlight significant or interesting findings along with P values for statistical tests. Be sure to

include negative results and highlight the potential limitations of the paper. The reviewers will criticize you if you don't discuss the shortcomings of your research. This often makes up for a great discussion section, so do not be afraid to highlight them.

Your research paper's results and discussion section should include the following: Findings, Comparison with prior studies, Limitations of your work, Casual arguments, Speculations, and Deductive arguments.

3.1 Data Collection and Problems

Data collection is an important stage that determines the success of a study, where researchers gather relevant and accurate information to answer the research questions that have been formulated. In the context of loading and loading, data collection is a solid foundation for understanding the challenges and opportunities associated with this process, as well as helping to develop effective strategies to optimize load performance and efficiency. During the research process at PT. XYZ, data collected from the company and observations in the field. Based on the loading process using one server (checker), the loading process of PT. XYZ is categorized as an M/M/1 type queue, according to the company's data regarding the loading process that has occurred. The researcher collected important data during the loading process to be applied into the ProModel software to align the research objectives, which is to optimize the truck queue during loading by adding one loading dock. The following data was collected:

a. Truck Arrival Data

Figure 2. Describes the fluctuation in the number of truck arrivals during the operating hours of the PT. XYZ:

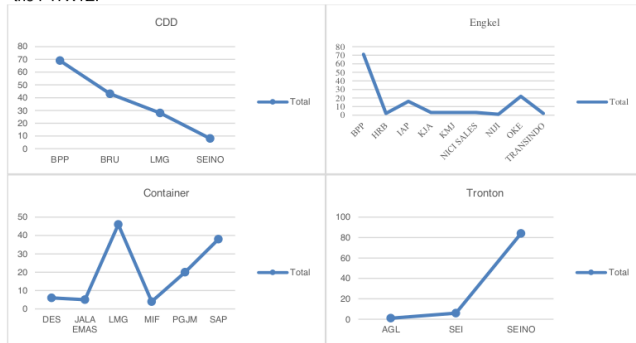


Fig. 2 Truck Arrival Data

b. Warehouse Information Data

Table 2 Contains warehouse information of PT. XYZ, which consists of operating hours and warehouse dimensions.

Table 2 Warehouse Information Data

Depot	Operating Hours	Dimensi Warehouse	Loading Dock Size	CDD	Pallet Size Ankle	100cm x 120cm Container	Tronton
Warehouse	SHIFT 1 (07:00 - 15:00)	30cm x 48cm x 8m	12m x 6m	16 Pallet	45 Pallets	28 Pallets	52 Pallets
	SHIFT 2 (15:00 - 23:00)						

Source: Field Survey Data

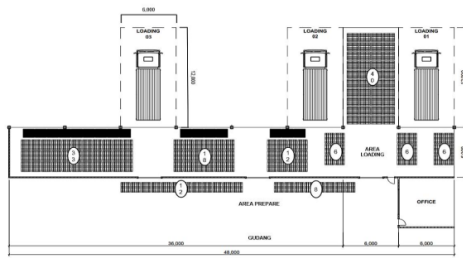


Fig. 3 Existing Loading Dock Layout

c. Transport Truck Information Data

The haul truck information is detailed in Table 3, loading size, capacity, loading time, vehicle speed, loading cost, and fix cost of each truck.

Table 3 Transport Truck Information Data

It	Kind	Dimensions (cm)	Capacity (Tons)	Loading Time (seconds/Ton)	Vehicle Speed (m/h)	Whole Fit Portion Armada
1	CDD	5300 x 2000 x 2100	5 Tone	3981	500 - 700	48%
2	Ankle	2000 x 1500 x 700	12 Tone	7395	450 - 650	18%
3	Container	1219,2 x 243,8 x 259,1	10 Ton	8968	400 - 600	18%
4	Tronton	1200 x 300 x 300	20 Ton	4684	400 - 550	16%

Source: Field Survey

d. Seasoning Information Data

Table 4 explains that each product of PT. XYZ.

Table 4 Seasoning Information Data

Product Name	Size / Timing per Box	Number of Boxes/pallet	Pallet mass (kg)
Sambal and Tomato Sauce Source: Company Data	Pet = 135 ml x 48 pcs	70	453.6 kg
	Tanggung = 275 ml x 24 pcs	70	462 kg
	Botol = 335 ML 12	40	160.8 kg
	Bag = 8 gr x 504 pcs	75	302.4 kg
Sambal Rumah Source: Company Data	Bag = 200 gr x 12 pcs	88	211.2 kg
Kecap Source: Company Data	Pet = 135 ml x 48 pet	70	453.6 kg
	Bear = 275 ml x 24 bear	70	462 kg
	Sachet = 225 ml x 12 Sachet	60	162 kg
	Gallon = 5, 7 x 4 pcs	20	456 kg
	Pack = 520 ml x 12 pack	60	374.4 kg

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Product Name	Size / Timing per Box	Number of Boxes/ pallet	Pallet mass (kg)
Special Ready-to-Eat Seasoning Source: Company Data	Pack = 45 gr x 24 pcs 6 box	36	233.3 kg
Ready to Eat Seasoning – Potatoes Source: Company Data	Pcs = 25 gr x 20 pcs	96	48 kg
Ready-to-eat Seasoning Source: Company Data	Packs = 33 gr x 200 packs	40	264 kg
Seasoning Source: Company Data	Pcs = 250gr x 24 pcs	77	462 kg
Seasoning Source: Company Data	Pcs = 10 gr x 288 pcs	96	276.48 kg
Seasoning Flour Source: Company Data	Cube = 20 gr x 100	120	240 kg
Seasoning Source: Company Data	Sachet = 75 gr 120 packs	35	315 kg
Seasoning Source: Company Data	Wrap = 210 gr x 24 pcs	54	272.16 kg

3.2 Development of Existing System Simulation Models

The following are the inputs in creating an existing system simulation model carried out with ProModel software:

a. Entities

In the ProModel software, the entities are populated as shown by the following figure:

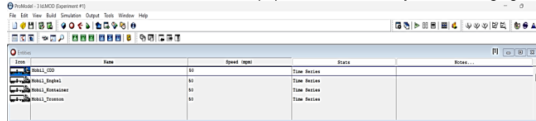


Fig. 4 Existing Entities

b. Location

In the ProModel software, the location is filled in as shown in the following figure.

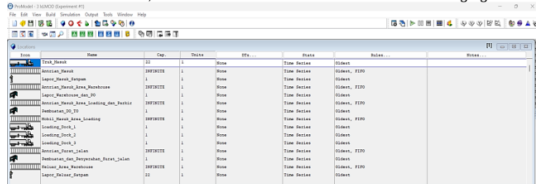


Fig. 5 Existing Location

c. User Distribution

In the ProModel software, the user distribution is filled in as shown in the following figure.

Percentage	Value
40	1.0
10	3
10	4
10	2

Fig. 6 Existing user distribution

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d. Arrival Cycle

The ProModel Arrival Cycle software is filled in as shown in the following figure.

ID	Name	Quantity	Unit	Status
001
002
003
004

Fig. 7 Existing Arrival Cycle

e. Arrival

The ProModel Arrival software is filled in as shown in the following figure.

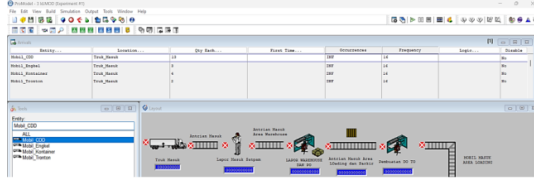


Fig. 8 Existing Arrival Cycle

f. Processing

The Processing software is filled in as shown in the following figure.

ID	Name	Duration	Status
001
002
003
004
005

Fig.9 Existing Processing

g. Variable

The Processing software is filled as shown by the following figure:

Name	ID	Type	Value
...
...

Fig. 10 Existing Variables

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h. Macros

The Macros software is filled in as shown by the following figure:

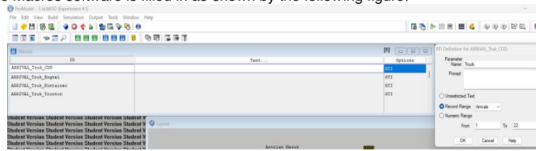


Fig. 11 Existing Macros

i. Layout Model

The Layout Model software is filled in as shown in the following image:

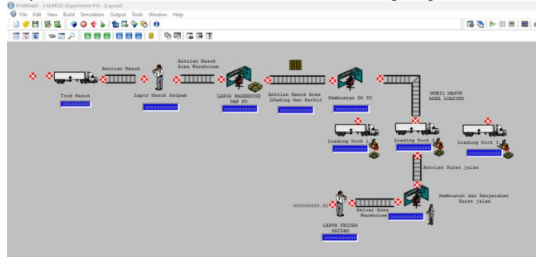


Fig. 12 Existing Model Layout

j. Validation Test

This simulation model is valid and able to represent the actual loading and loading system well. This successful validation gives confidence that the model can be used to conduct further simulation experiments to optimize workflows and improve operational efficiency at the facility.

k. Summary of Existing Modeling Results

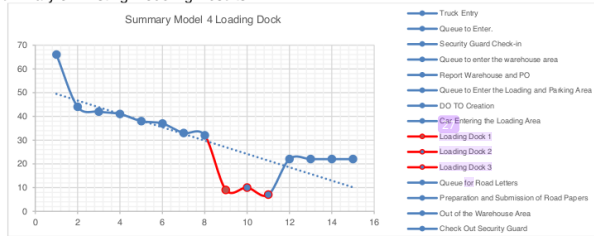


Fig. 13 Summary Scenario 1

From an operational perspective, this study indicates that in order to achieve maximum efficiency improvement, in addition to adding loading docks, it is necessary to make improvements in the administrative process related to the elimination of DO waiting time.

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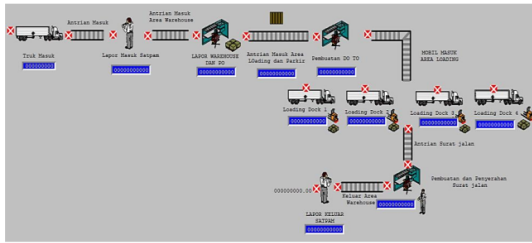


Fig. 15 Relayout of Scenario Simulation Model with 4 Loading Docks

- b. The Danger of Scenario 1
 The following is the result of the Entity States-Baseline Output from the proposal with 4 Loading Docks using ProModel software

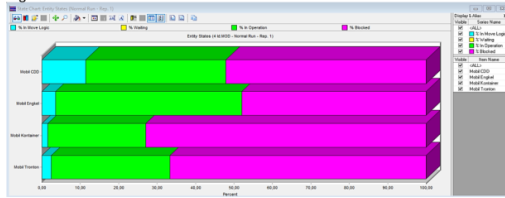


Fig. 16 Diagram Output Entity States-Baseline

The following are the results of the Scoreboard Output of the proposed 4 Loading Dock using ProModel software.

Tabel 6. Output Scoreboard 4 Loading Dock

Name	Total Exits	Average Time In System (Min)	Average Time In Operation (Min)
Mobile CDD	20	367,62	133,92
Car Ankle	3	423,08	205,33
Container Car	6	671,61	171,42
Tronton Car	3	777,41	239,93

The results of the Single Capacity Location State-Baseline Output and the Multiple Capacity Location State-Baseline of the proposed 4 Loading Dock using ProModel software.

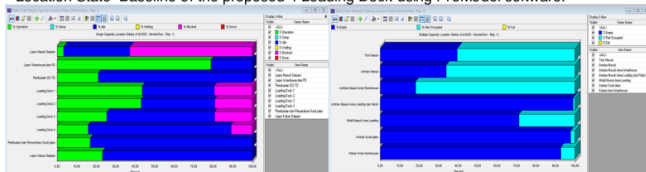


Fig. 17 Diagram Output Single Capacity

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After the analysis using the ProModel, here are the summary results from Scenario 1:

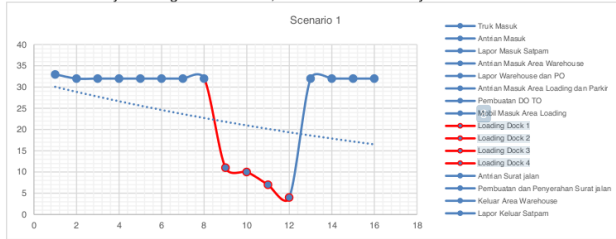


Fig. 18 Summary Scenario 1

The scenario has significant results according to the Improve Truck Arrival data on 4 Loading Docks that have been created with a total of 32 trucks/day with a significant reduction in queues on each Loading Dock showing the Exponential distribution flow.

c. The Perils of Scenario 2

After the analysis using ProModel, here is a summary of the results of the implementation:

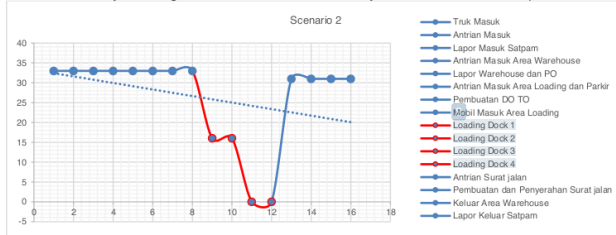
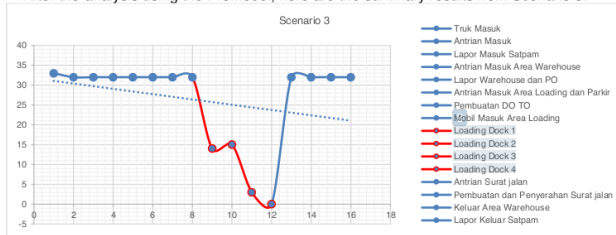


Fig. 19 Summary Scenario 2

Scenario 2 is not significant and does not match the Improve Arrival data of 4 Loading Dock Trucks with a total of only 31 trucks/day in Scenario 2.

d. The Devil's Nest 3

After the analysis using the ProModel, here are the summary results from Scenario 3:



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Fig. 20 Summary Scenario 3

The scenario has significant results according to the Improve Truck Arrival data on 4 Loading Docks that have been made with a total of 32 trucks/day. However, there is too little loading activity that occurs in Loading Dock 4 so that it is not efficient to propose in depth.

e. Validation Test

Based on the results of the three scenarios that have been carried out, Scenario 1 can be used as the most effective proposal and a validity test is carried out.

Based on replication tests

Table 7 Calculation of Many Replication of Loading and Loading Process

Replication	Real System Time (minutes/loading)	$(X_i - \bar{X}_{rata})^2$
1	78,95	197,09
2	78,50	209,93
3	121,52	813,83
4	92,99	0,00
Average	92,99	
S. Deviation		352
Lots of Replication		156

Based on the validity test, the following t-stat results of the Loading and Loading Process:

Table 8 T-Stat Validity Test of Loading Process 4 Loading Dock

	Real Time	ProModel
Mean	220,8214286	220,3730471
Variance	162976,6399	163075,7216
Observations	7	7
Pearson Correlation	0,999999127	
Hypothesized Mean Difference	0	
df	6	
t Stat	2,166666667	
P(T<=t) one-tail	0,036699328	
t Critical one-tail	1,943180281	
P(T<=t) two-tail	0,073398656	
t Critical two-tail	2,446911851	

The table above shows that the t-stat value is smaller than the two-tail critical t-value, which means that H₀ is accepted, so the runtime data on the real system in the Loading and Loading process can be said to be valid.

Based on the verification test, it is revealed that the simulation model can accurately describe the variation in truck flow and dock utilization, with stable and reliable simulation results through repeated replication. With this verification, the simulation model is considered valid and can be used as an effective tool to conduct simulation experiments to identify opportunities to improve operational efficiency and optimize the management of loading docks at the facility.

3.4 Research Results

Through Scenario 1, a simulation was held to understand the effect of adding loading docks on throughput, wait time, and resource usage. The simulation results show that by adding one loading dock, the number of vehicles that can be serviced per day increases significantly, from an average of 22 vehicles to 32 vehicles, which represents a 45% increase in throughput. Vehicle wait times have also been reduced from about 18 minutes to 9.3 minutes, leading to an increase in overall efficiency.

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In addition, the validity analysis conducted shows that the simulation model accurately replicates the loading and unloading operations that occur in real distribution facilities. Validity tests and statistical tests performed, including t-tests, confirm that the simulated data and the actual data have a good fit, with acceptable differences. The increase in resource usage and the reduction of total cycle time from an average of 114 minutes to 104 minutes shows that the addition of a loading dock not only improves efficiency but also optimizes labor utilization.

Overall, the results of the study confirm that the addition of a loading dock is an effective solution to overcome bottlenecks in the loading and unloading process. Investing in adding loading docks has proven to provide great benefits in terms of operational performance, reduced wait times, and increased productivity. By using ProModel as a simulation tool, this study proves that the addition of these facilities can have a significant positive impact on the operational efficiency of distribution facilities.

4. Conclusion

This research aims to optimize truck queues in the loading and unloading process at PT. XYZ using discrete simulations with ProModel. By adding one loading dock to four, the simulation results showed a 45% increase in facility throughput, from 22 trucks/day to 32 trucks/day. Model validation is performed by comparing the simulation output with historical data, showing accurate and reliable results. The simulation also identifies bottlenecks in truck flow and provides an optimal solution to reduce truck wait times from an average of 18 minutes to 9.3 minutes, as well as reduce the total cycle time for loading and unloading from 114 minutes to 104 minutes.

The results reveal that optimization can be achieved through the addition of loading docks and more efficient truck flow management. The implementation of the ProModel simulation model provides valuable insights for PT. XYZ to improve dock loading management, speed up the loading process, and reduce truck waiting time. These findings show that the use of discrete simulation is an effective tool in identifying and overcoming operational problems, so that it can be implemented to improve the efficiency and productivity of loading and unloading facilities at PT. XYZ significantly.

In conclusion, this study successfully shows that the use of discrete simulation with ProModel is an effective tool to identify and overcome problems in the loading and unloading process and truck queue process at PT. XYZ. With model validation that shows accurate and reliable results, the recommendations from this simulation can be implemented to improve operational efficiency and optimize the performance of loading facilities. The implementation of suggestions such as the addition of loading docks, bottleneck analysis, and regular workforce training will help PT. XYZ in improving efficiency and productivity, and ensuring continuous operational improvements in the future.

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