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Combination of Value Stream Mapping and Vehicle Route Mapping: A Case Study of Internal Logistic Optimization

Kombinasi Value Stream Mapping *dan* Vehicle Route Mapping*:* *Studi Kasus Optimasi Logistik Internal*

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Abstract

This study offers a solution to improve internal logistics efficiency, particularly trucking activities between buildings in a manufacturing environment. It applies three methods, that is Value Stream Mapping (VSM) to eliminate non-value-added (NVA) activities and reduce truck usage time, Capacity Analysis to optimize truck fill rates and minimize the total number of trips, as well as Vehicle Route Mapping (VRM) to select the shortest route and reduce travel time. As a result, PT. Sumarna reduced its internal trucks from 10 to 5 units, achieving a 47.15 percent of cost efficiency. The study is limited to internal trucking for goods with uniform dimensions and long shelf life, excluding volume fluctuations. This research highlights the effectiveness of combining VSM and VRM in internal logistics and serves as a benchmark for similar manufacturing settings that require internal transport between distributed buildings.

Keywords: Internal Logistic, Internal Trucking, Truck Utilization, Value Stream Mapping.

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Abstrak

Studi ini menawarkan solusi untuk meningkatkan efisiensi logistik internal, khususnya aktivitas pengangkutan barang antar gedung dalam lingkungan manufaktur. Studi ini menerapkan tiga metode, yaitu Value Stream Mapping *(VSM) untuk menghilangkan aktivitas yang tidak menambah nilai (NVA) dan mengurangi waktu penggunaan truk, Analisis Kapasitas untuk mengoptimal kan tingkat pengisian truk dan meminimalkan jumlah perjalanan total, serta* Vehicle Route Mapping *(VRM) untuk memilih rute terpendek dan mengurangi waktu perjalanan. Hasilnya, PT. Sumarna berhasil mengurangi jumlah truk internal dari 10 menjadi 5 unit, dengan efisiensi biaya sebesar 47,15 persen. Studi ini terbatas pada pengangkutan barang dengan dimensi seragam dan masa simpan yang panjang, tanpa mempertimbangkan fluktuasi volume. Penelitian ini menyoroti efektivitas kombinasi VSM dan VRM dalam logistik internal dan dapat dijadikan acuan bagi lingkungan manufaktur serupa yang memerlukan pengangkutan internal antara gedung-gedung yang tersebar.*

Kata Kunci*:* Logistik Internal, Pengangkutan Truk Internal, Pemanfaatan Truk, *Value Stream Mapping.*

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INTRODUCTION

With an estimated yearly production of over 83 billion cigarettes in 2024, PT. Sumarna is the biggest tobacco firm in Indonesia. Based on sales statistics from the previous nine (9) years, PT. Sumarna's production volume, market share, and profit have all suffered from an annual increase in the excise duty of 10.85 percent (PT. Sumarna, 2024). The company has lost more than 24 percent of its volume over the past nine years, despite revenue and selling prices rising in tandem. With a 39.39 percent drop in profit in 2023 compared to its peak in 2016, the decline in earnings is significantly worse (PT. Sumarna, 2024).

10 (ten) 40-foot truck units move finished goods and raw materials from warehouses in Lot 17 (Warehouse Area) to manufacturing facilities in Lot 41, and vice versa (PT. Sumarna, 2024). According to math, there will be a 27 percent of cost savings if three of ten (10) internal vehicles now used to move finished items and raw materials from warehouses in Lot 17 (Warehouse Area) to production facilities in Lot 41 and vice versa are removed. But cutting the number of truck units suddenly without giving it any thought or doing the math could lead to a drop in service quality and a risk of production disruption, which could lead to a greater loss of capacity (Yazdanparast *et al*., 2022).

LEAN tools and vehicle route problem analysis are used in tandem to optimize the internal transportation operation. The existing scenario is analyzed using finding gaps and productivity using the Value Stream Mapping (VSM) approach (Batwara *et al*., 2023). In order to cut internal transportation costs by 27 percent, the primary objective of this study is to assess PT. Sumarna's internal trucking value-added (VA) and non-value-added (NVA) activities, as these activities significantly affect the company's overall operating costs.

Value stream mapping, on the other hand, is primarily concerned with eliminating as many non-value-added process wastes as feasible and cutting costs associated with them without compromising safety and quality. Value should be created at every stage of the supply chain operations that provide goods and services to clients. A step should be eliminated from the process if it adds no value (Knoll et al., 2019).

Rohac & Januska (2015) reduced the lead time from 296 to 96 days and illustrated the Value Stream Mapping technique in a real-world case study. As a direct result, the inventory value decreased by as much as 276,000 EUR. Prior research indicates that no study has simultaneously looked at capacity, time consumption, and distance optimization in a logistic operation. To achieve even higher process productivity, this study will combine Vehicle Route Mapping (VRM), Capacity Analysis (CA), and Value Stream Mapping (VSM). VSM will be used to eliminate Non Value Added (NVA) activities in order to reduce truck time utilization; VRM will be used to define least distance routing in order to reduce traveling time; and, CA will be used to optimize truck fill rate in order to reduce the overall number of trips required.

LITERATURE REVIEW

Each significant link in the value chain is represented by a rickety number of icons in the VSM, a graphic technique (Bock *et al*., 2025). Every component or procedure in the value chain has its time documented. Mapping the end-to-end value chain can help determine the total process cycle time and the proportion of that time that is Value Added (VA), which adds value to the product or service (Hu *et al*., 2024). VA time is easily computed by consistently applying VA procedures from start to finish. The NVA time is also calculated using the same methodology.

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Value stream mapping (VSM) is a two-step procedure that shows the process's "current state" and its potential "future state" (Fabri & Ramalhinho, 2024). The goal of the "current state" map is to accurately and thoroughly depict the present value chain. When it comes to following decision-making and process-improvement procedures, this "current state" map is helpful. However, the "future state" map shows the sample process in its best conditions and with enhancements, removing or reducing NVA from the image. Lean tools like Pokayoke, 5S, and Single-Minute-Exchange-Dyes (SMED) are used to improve the process.

The phrase "Truck Fill Rate" will be used in this investigation. The effectiveness of space utilization in a container is defined by the truck fill rate (Nikolova & Nterai, 2023). In this study, truck fill rate will be calculated by dividing loaded capacity actual in a trip with its respective maximum capacity in a trip (Ahmad *et al*., 2022). When the truck fill rate reaches or above the desired capacity during a journey, it will be deemed "Full".

One of the primary issues in logistic operations is the Vehicle Routing Problem (VRP) (Putri, 2017). A fleet of vehicles' best routes to service a specific group of consumers are determined by the VRP (Masudin *et al*., 2019; Mohammed *et al*., 2017; Zhang *et al*., 2019). The VRP is one of the most crucial combinatorial optimization issues to examine in the logistics sector (Eshtehadi *et al*., 2020; Utama *et al*., 2020). Research on VRP problems was pioneered by Hsu *et al*. (2007), Kang & Lee (2007), and Tarantilis & Kiranoudis (2001).

METHOD

Quantitative data will be gathered through various sources, starting with the current truck utilization data, which is recorded by the drivers and warehouse personnel for each trip (Shamsuzzoha *et al*., 2020). Data on the current route map will be collected through measurements to identify the trip routes and the distances between the warehouses. Another key data source will be the current step process data, which includes the loading/unloading process, parking/de-parking process, administrative process, and the traveling process (Chirumalla *et al*., 2022). This data will be collected through direct observations conducted by several observers, each tasked with recording the activities of workers during normal operations. These observations will be mapped using tools such as the Spaghetti/Travel Material Diagram, which visually represents the physical movements of activities to identify redundancies and inefficiencies in workplace arrangements (Al-Zubaidi *et al*., 2022). Additionally, a Time Observation Sheet will be utilized to record the amount of time needed for every movement, and observers will be outfitted with stopwatches to record exact times.

A quantitative analysis method was used for this study. Vehicle route problem analysis and Lean methods are combined to optimize the internal transportation operation (Rohac & Januska, 2015). The framework is divided into four (4) main stages.

First stage is current state mapping using VSM. In order to uncover gaps and productivity opportunities, the research began with a comprehensive examination of the current state of affairs using the value stream mapping (VSM) approach (Reda & Dvivedi, 2022). Since internal trucking has a major impact on PT. Sumarna's overall operating costs, especially when it comes to internal transportation costs, this study will mainly focus on assessing the company's internal trucking value added activities (VA) and non-value added activities (NVA). At this point, a current state map will be created using observation data.

Second stage is process improvement by using LEAN toolbox. After identifying and measuring the gap and productivity potential based on the current state map (CSM), the researchers will review

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pertinent literature on the LEAN tools technique to optimize the cycle time. The remaining VA and Business Non Value Added (BNVA) operations that cannot be removed from the process due to safety or quality constraints can be optimized using LEAN techniques. The cycle time will be reduced as a result (Kihel *et al*., 2022). This study can benefit from the following Lean tools: (a)One-minute die exchange (SMED), which is a fast loading and unloading procedures are anticipated while implementing internal and external activities in order to shorten the cycle time for every internal truck unit; (b)Five Reasons, which identifies the true goal or underlying cause of every BNVA activity and coming up with solutions to enhance and streamline the procedure; and, (c)5S Design, namely the warehouse dock plan to eliminate needless movement and transport in order to maximize loading and unloading efficiency and save time.

Third stage is Truck Fill Rate analysis. By comparing takt time with the optimized cycle time from step 2, the researchers will do a capacity and utilization analysis on the number of inbound truck units needed to supply the demand from all manufacturing locations combined. To ascertain whether merging trips could reduce the total number of trips, the fill rate of each truck unit will be investigated (Hassan & Helo, 2021). Last stage is Vehicle Route Problem analysis. For each incoming truck unit that remains, an optimum route must be built up because the number of trucks will be reduced. The traveling salesman problem model analysis will be used in this mapping to determine the shortest distance traveled by a number of possible combinations (Reda & Dvivedi, 2022).

RESULTS

Current State Mapping

At this current state mapping stage, the first step is to do the current stream map where the current cycle time of a typical single trip is mapped using value stream mapping (Knoll *et al*., 2019). For a single trip, the current state map is shown in Figure 1. Every trip necessitates a number of waiting periods before warehouse employees may load or unload it, as the current stream chart illustrates. The waiting time for a single trip is more than 33 minutes, which means that each trip takes 164.4 minutes on average.

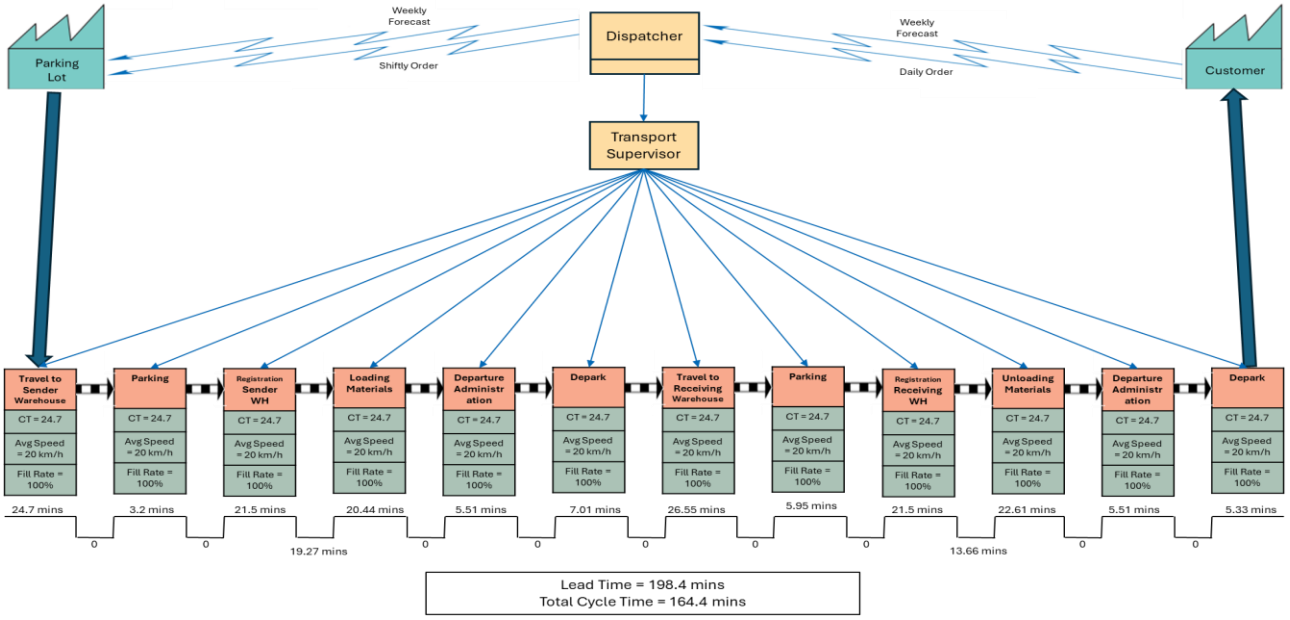


Figure 1. Current State Map
Source: Secondary data (processed), 2024.

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Table 1. Current Truck Time Utilization

Truck	Available Time/day	Travel	Park/Depark	Administration	Loading/ Unloading	Waiting	Cycle Time
DIM PMID 1	1290	18.01	11.91	16.37	47.44	33.81	127.5431
DIM PMID 2	1290	18.01	11.91	16.37	47.44	33.81	127.5431
DIM PMID 3	1290	18.01	11.91	16.37	47.44	33.81	127.5431
FGW PMID 1	1290	20.16	11.50	10.65	52.81	25.33	120.4371
FGW PMID 2	1290	20.16	11.50	10.65	52.81	25.33	120.4371
FGW PMID 3	1290	20.16	11.50	10.65	52.81	25.33	120.4371
SPP	480	16.04	12.18	18.62	62.23	0.00	109.0705
RRP DIM	1290	23.00	10.50	18.45	49.27	21.25	122.4682
FG – SFG SFP	1290	23.00	10.60	18.64	57.61	0.00	109.8443
INGREDIENT	630	10.30	7.95	10.20	27.96	7.28	63.68414
AVERAGE	11430						

Truck	Occupied Trip/day	Empty Trip/day	Utilized Time	% Time Utilization	Operating Time	% Time Utilization
DIM PMID 1	6	4	884.9363	68.6	682.092	52.9
DIM PMID 2	6	4	884.9363	68.6	682.092	52.9
DIM PMID 3	6	4	884.9363	68.6	682.092	52.9
FGW PMID 1	7	6	1032.984	80.1	855.7008	66.3
FGW PMID 2	9	4	1210.55	93.8	982.6142	76.2
FGW PMID 3	7	6	1032.984	80.1	855.7008	66.3
SPP	4	1	464.5024	96.8	464.5024	96.8
RRP DIM	8	4	1113.746	86.3	943.7459	73.2
FG – SFG SFP	10	0	1098.443	85.2	1098.443	85.2
INGREDIENT	8	5	600.743	95.4	542.503	86.1
AVERAGE			9208.762	80.6		68.1

Source: Secondary data (processed), 2024.

Table 2. Current Truck Fill Rate

Truck	Average load capacity (pallet)	Fill Rate - Full / Non Full
DIM PMID 1	25	Full
DIM PMID 2	1098.25	Full
DIM PMID 3	25	Full
FGW PMID 1	20	Full
FGW PMID 2	20	Full
FGW PMID 3	20	Full
SPP	33	Full
RRP DIM	20	59 percent
FG - SFG SFP	15	Full
INGREDIENT	6	Full

Source: Secondary data (processed), 2024.

Next, current truck time utilization is calculated. Ten trucks are employed to support materials and completed goods transportation throughout the factory in order to support PT. Sumarna's daily operations. PT Sumarna employs a third-party transportation company that accepts rental hour

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payments. Table 1 shows each truck's current available time and time use. Optimizing the current truck fill rate and time use is the aim of this study. The "real" current truck time utilization is 68.1 percent after excluding the non-value-added waiting time for loading and unloading throughout each warehouse procedure, which is still included in this number. Currently, each truck's average time utilization is 80.6 percent, according to the data.

The last step in this stage is to calculate the current truck fill rate. Based on the information in Table 2, with the exception of RRP DIM, which has a truck fill rate of 59 percent, the majority of trucks have a "full" truck fill rate for each trip. Truck fill rate optimization may result in fewer trips needed each day or fewer trucks needed overall (Hassan, 2021).

Work Process Improvement

In this stage, the first step is to do NVA analysis. Based on Table 1, it is shown that “real” current truck time utilization is 68.1 percent which relatively low. This suggests that the journey might be rearranged to maximize the time spent by each truck and decrease the overall number of vehicles required (Fabri & Ramalhinho, 2024). NVA Analysis is used to deep dive deeper to the process steps to identify whether there are unnecesary steps or process waste in current 68.1 percent of time utilization to draw out increased potential of truck reduction.

In order to record all of the step activities and their corresponding durations in a Time Observation Sheet, time-and-movement observations are made for each of the primary processes. Next, each step's activities are categorized as either necessary non-value-added (NNVA), non-value-added (NVA), or value-added (VA) (Kihel *et al*., 2022). Classification for each process and activites are shown in Table 3. Every activity category was compiled and examined. Table 4 displays the current state of each process based on the NVA analysis. On average, 50 percent of NNVA needs to be examined and decreased, and 15 percent of NVA needs to be removed. Brainstorming is used to find ideas for improvements that will lower NNVA and eradicate NVA. Table 5 displays a number of initiatives that were discovered throughout the brainstorming phase. Cycle time can be shortened by 29.3 minutes by putting a number of countermeasures into place. Table 5 summarizes the effects of each initiative on cycle time and the optimal VA, NVA, and NNVA states of each activity.

Table 3. Process Step Classification

Process	VA -Value Added	NNVA - Necessary Non Value Added	NVA - Non Value Added
Travelling	Moving Goods with Internal Trucks	Vehicle Verification Vehicle Checking by Security	Queueing
Park/Depark	Giving Parking Instruction Container Opening Docking	Getting tools : Megaphone, 2 Steps lac Put on wheel choke Put vehicle keys in security post	Unnecesary movement to get tools
Administration		Walking Delivery Note Verification	Waiting for Admin Waiting for goods receipt process
Loading / Unloading	Move goods/materials from inside truck	Truck checking prior unloading Move pallet to distant staging area Visual Inspection each pallet Barcode Scanning each pallet Checklist filling Checklist submission to admin	Prepare Forklift Printing unloading checklist Walking without task Unnecessary movement

Source: Secondary data (processed), 2024.

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Table 4. Current NVA Analysis

Activities	%VA	%NVA	%NNVA	%Total
Traveling	60.8	15.4	23.8	100.0
Park / Depark	52.3	14.3	33.6	100.0
Administration	0.0	26.7	73.3	100.0
Loading / Unloading	22.3	4.6	73.1	100.0

Source: Secondary data (processed), 2024.

Table 5. NVA Initiatives

Activities	Countermeasure	Cycle Time Reduction (minute)	%VA	%NVA	%NNVA	%Total
Traveling	1. Time window for each truck to prevent queue at the same time	2.7	100	0	0	100
	2. Reduce checking procedure at main gate	2.2				
Park / Depark	1. Dedicated supporting tools for each dock to reduce movement 2. Visualization at docks to standardized optimum sequencing 3. Training materials creation and sharing to internal drivers - injected into new driver's induction material	3.3	65	0	35	100
Administration	1. WMS Integration	2.9	0	0	100	100
	2. Offline GR Process	4.2				
Loading / Unloading	1. Define temporary staging location at loading dock area 2. Time-window schedule implementation 3. Document preparation in advance 4. Standard matrix for points of visual checking	14	35	0	65	100

Source: Secondary data (processed), 2024.

The second step in this stage is to compile the Future Stream Map. Figure 2 displays the map for a single journey. Waiting time and NVA are eliminated, while essential NNVA are decreased, it cuts the overall cycle time from 164.4 to 82 minutes and the lead time from 198.4 to 82 minutes. Truck usage would drop to 56.2 percent if cycle times for each procedure were shortened. This suggests that the route might be rearranged to maximize the time spent by each truck and decrease the overall number of vehicles required (Fabri & Ramalhinho, 2024). The number of trucks required to maintain service level to production at the current level is then determined using simulations.

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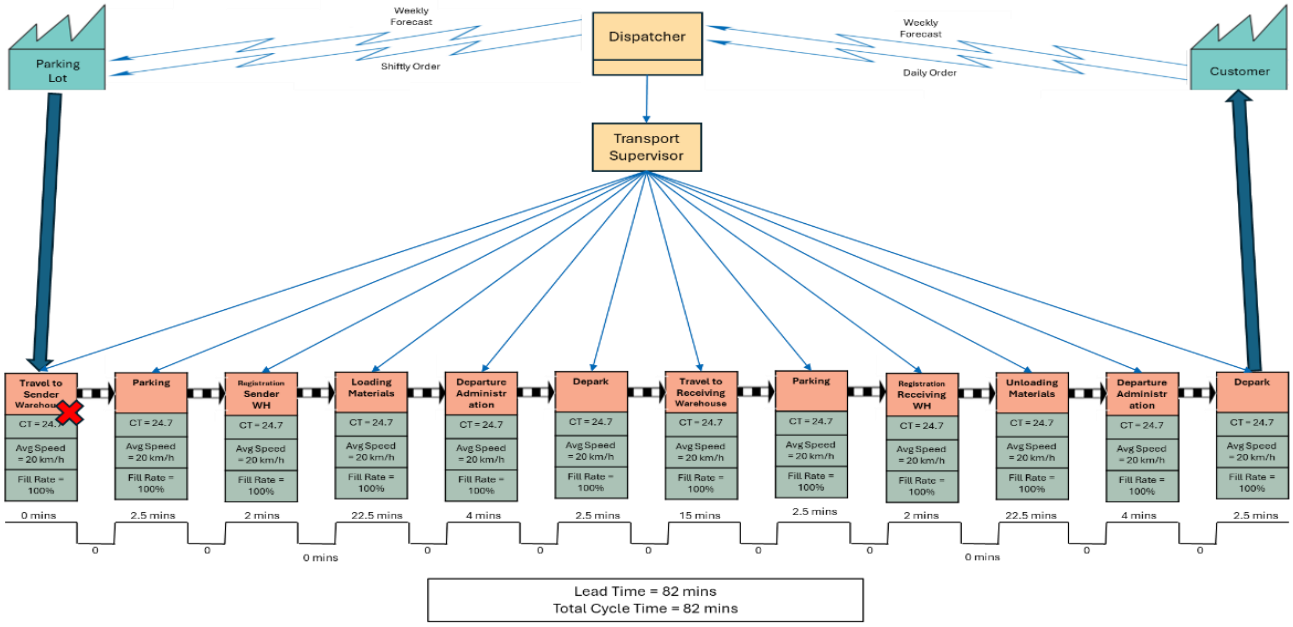


Figure 2. Future Stream Map Map
Source: Secondary data (processed), 2024.

Table 6. Truck Number Requirement from NVA Reduction

	# Unit	Utilization (%)	Reduction unit 24 hours	Reduction unit 12 hours	Reduction unit 8 hours	# Unit New	Future Utilization (%)
Exclude Waiting	10	68.1	2	1	0	8.0	94.1
NVA Analysis	10	56.2	3	1	0	7.0	91.5

Source: Secondary data (processed), 2024.

Table 6's computation allows for a three-unit reduction in the number of vehicles and a one-unit reduction in the rental period from a 24-hour to a 12-hour scheme. This is noticeably greater than what would happen if we simply eliminated the waiting period without conducting an NVA study and putting process improvement into place. This demonstrates NVA analysis's strength (Kihel *et al*., 2022). Only two trucks will need to be trimmed in the absence of an NVA analysis, and one unit's rental term will be shortened from a 24-hour to a 12-hour schedule. Utilization will exceed 100% and the service level will be compromised if the number of units is cut by four.

Truck Fill Rate Optimization

The next stage is to compile a mapping of the average Truck Fill Rate for each trip and route, which is shown in Table 7. Finding non-full journeys in PT. Sumarna's internal logistic travels is the aim of this investigation. It is anticipated that merging many partial journeys will result in fewer trips overall and less truck time usage (Yazdanparast *et al*., 2022). Additional truck rental cost savings result from reduced truck time use. The bulk of PT. Sumarna's internal logistic journeys are filled, according to truck fill rate data. There is a chance to cut down on the number of trips for many routes:

- Ingredients to KR07 that only supply one pallet utilizing a 40-foot container can be removed, and MHE can be used to transfer them straight from the Ingredient Warehouse to the production floor.
- The number of trips from KR09 to DIM RRP 41 can be reduced from 11 to 9 per day by optimizing the use of a 40-foot container with a 59% fill rate.
- It is possible to optimize DIM RRP 41 to KR09 utilizing a 40-foot container with a 44% fill rate, reducing the number of daily trips from six to four.

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Table 7. Truck Fill Rate Optimization Scheme

Current Trip					Future Trip Reduction		
Origin Warehouse	Destination Warehouse	Average Fill Qty (pallet)	Target Minimum Capacity (pallet)	Fill Rate – Full / Non Full	Current Trip Per Day	-1	-2
KR07	DIM PMID 4	24.8	24	Full			
FGW PMIID	LC	19.9	20	Full			
SPP	KR07	32.7	34	Full			
SPP	DIM RRP 41	20	24	59%	11	65%	Full
DIM RRP 41	KR09	14.9	24	44%	6	53%	Full
PPK	PPW	36.6	34	Full			
PPW	Ingredient	6.1	7	Full			
Ingredient	PPK	5	7	Full			
Ingredient	PPW	5	7	Full			
Ingredient	KR07	1	34	3%		Eliminate	

Source: Secondary data (processed), 2024.

Table 8. Truck Number Requirement from NVA reduction + Fill Rate Optimization

	# Unit	Utilization (%)	Reduction unit 24 hours	Reduction unit 12 hours	Reduction unit 8 hours	# Unit New	Future Utilization (%)	Annual Cost Saving ($)
Exclude Waiting	10	68.1	2	1	0	8.0	94.1	154,838.71
NVA Analysis	10	56.2	3	1	0	7.0	91.5	210,967.74
NVA Analysis + Fillrate Optimization	10	52.6	4	0	0	6.0	94.1	224,516.13

Source: Secondary data (processed), 2024.

To make sure the combined trips won't cause a warehouse overload or process disruption, an analysis of the source and recipient warehouse capacities is done before combining trips. The inbound truck time utilization will drop to 52.6 percent once fewer trips are made by optimizing the truck fill rate (Table 8). Because of this decreased utilization, a number of units can be reduced in order to increase the use of each truck unit that remains. When NVA analysis and Fill Rate analysis are combined, the required number of trucks is further decreased to 6 units, compared to 7 units when NVA analysis is done alone. To account for small process changes, the target for each truck's future usage is 90 percent.

Vehicle Route Mapping

As of the now, PT. Sumarna's internal logistic process has 37 empty trips every day (Table 9). The primary cause of this is the return trips made once items are sent from warehouse A to warehouse B and back again. Numerous synchronizations between warehouses are identified, and combinations of truck routes are simulated. The optimal trip sequence is achieved by applying the Traveling Salesman Problem's Nearest Neighbor heuristic concept (Zhang *et al*., 2022). Table 10 displays the reallocation of existing routes.

Routes can be combined to limit the number of empty journeys by assigning each vehicle to its closest neighbor to load finished goods or other materials. The number of vacant trips in daily operations can be decreased to 26 in the best-case scenario. This application lowers the daily truck time use by up to 239.3 minutes and the overall trip distance by 49.7 kilometers (Table 11).

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Table 9. Current Total Trip Distance

	Count					Distance		
	Full	Fill Rate	Empty	Fill Rate (%)	Total	Full	Empty	Total
DIM PMID 1	6	Full	4	0	10	21.1	10.4	31.5
DIM PMID 2	6	Full	4	0	10	21.1	10.4	31.5
DIM PMID 3	6	Full	4	0	10	21.1	10.4	31.5
FGW PMID 1	7	Full	6	0	13	23.8	17.4	41.2
FGW PMID 2	9	Full	4	0	13	29.6	11.6	41.2
FGW PMID 3	7	Full	6	0	13	23.8	17.4	41.2
SPP	4	Full	1	0	5	10.5	3.7	14.2
DIM RRP	4	Full	3	0	7	39.8	17.2	57
FGW RRP	10	Full	0	0	10	47.5	0	47.5
INGREDIENT	7	Full	5	0	12	19.1	8.95	28.05
TOTAL	66		37		103	257.4	107.45	364.85

Source: Secondary data (processed), 2024.

Table 10. Route-Truck Reallocation

Route	Truck Current State	Truck Future State
Route 1a , Route 1b	DIM PMID 1 DIM PMID 2 DIM PMID 3	DIM PMID 1 COMBINE 1 (DIM PMID + FGW PMID)
Route 2a, Route 2b	FGW PMID 1 FGW PMID 2 FGW PMID 3	COMBINE 1 (DIM PMID + FGW PMID) FGW PMID 1
Route 3a, Route 3b, Route 4, Route 5	SPP	COMBINE 2 (RRP DIM + SPP)
Route 6a, Route 6b	RRP DIM	COMBINE 2 (RRP DIM + SPP)
Route 7a, Route 7b	FG RRP	COMBINE 3 (FG RRP + INGREDIENT)
Route 8a, Route 8b, Route 9a, Route 9b Route 10a, Route 10b, Route 11a, Route 11b	INGREDIENT	COMBINE 3 (FG RRP + INGREDIENT)

Source: Secondary data (processed), 2024.

Table 11. Future Total Trip Distance

	Count					Distance		
	Full	Fill Rate	Empty	Fill Rate (%)	Total	Full	Empty	Total
DIM PMID 1	14	Full	0	0%	14	44.1	0	44.1
FGW PMID 1	12	Full	8	0%	20	37.8	15.4	53.2
COMBINE 1	14	Full	5	0%	19	45.6	14.5	60.1
COMBINE 2	14	Full	3	0%	17	59.8	15.9	75.7
COMBINE 3	12	Full	10	0%	22	36.6	22.95	59.55
TOTAL	66		26		92	223.9	68.75	292.65

Source: Secondary data (processed), 2024.

Truck time will be used less when there are fewer empty journeys (Hassan, 2021). Time spent on trucks is reassessed. Using a six-truck scenario, truck time utilization is further decreased from 94.1 percent to 85.5 percent, making it feasible to further reduce the number of trucks from six to five. Table 12 illustrates that a smaller number of truck units (5) can cover all current routes compared to the prior ten (10) units.

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Table 12. Future Truck Time Utilization

Truck	Available Time per day	Travel Time	Park/Depark	Administration Time	Loading Unloading Time	Waiting
DIM PMID 1	1290	15	10	10	40	0
FGW PMID 1	1290	15	10	10	45	0
COMBINE 1	1290	15	10	10	45	0
COMBINE 2	1290	20	10	10	40	0
COMBINE 3	1290	20	10	10	40	0
	6450					

Truck	Cycle Time	Rit per day (fill)	Rit per day (empty)	Utilized Time	% Time Utilization
DIM PMID 1	75	14	0	1050	81.4
FGW PMID 1	80	12	8	1160	89.9
COMBINE 1	80	14	5	1245	96.5
COMBINE 2	80	14	3	1210	93.8
COMBINE 3	80	12	10	1269	97.7
				5925	91.9

Source: Secondary data (processed), 2024.

Table 13. Truck Number Requirement from NVA reduction + Fill Rate Optimization + Vehicle Route Mapping

	# Unit	Utilization (%)	Reduction unit 24 hours	Reduction unit 12 hours	Reduction unit 8 hours	# Unit New	Future Utilization (%)	Annual Cost Saving ($)
Exclude Waiting	10	68.1	2	1	0	8.0	94.1	154,838.71
NVA Analysis	10	56.2	3	1	0	7.0	91.5	210,967.74
NVA Analysis + Fillrate Optimization	10	52.6	4	0	0	6.0	94.1	224,516.13
NVA Analysis + Fill Rate Optimization + Vehicle Route Mapping	10	51.8	4	0	1	5.0	108	91.9%

Source: Secondary data (processed), 2024.

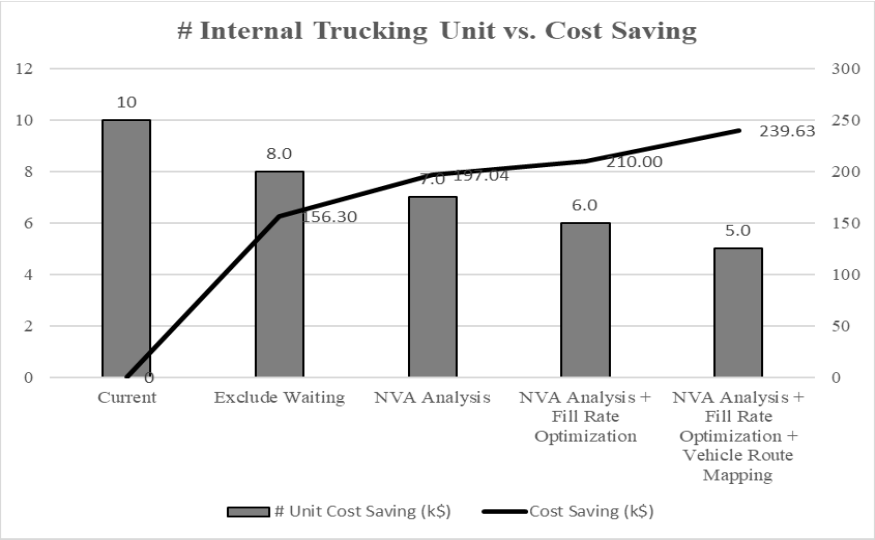


Figure 3. Comparison of Cost Saving

Source: Secondary data (processed), 2024.

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Truck time consumption is reassessed in order to confirm the reality. According to calculations, PT. Sumarna can use five internal trucks for material and finished goods supply operations, with an average time utilization of 91.9 percent, as indicated in Table 12.

Discusssion

This study shows that the methodological approaches used, namely Non-Value Added (NVA) analysis, Truck Fill Rate analysis, and Vehicle Route Mapping, are synergistically capable of identifying and reducing waste in PT. Sumarna's internal logistics processes. Each method has a specific contribution in uncovering inefficiencies from different dimensions. NVA analysis, which refers to the principles of Lean Management, helps identify activities that do not add value and should be eliminated from the process (Zhang *et al*., 2022). Meanwhile, Truck Fill Rate analysis highlights the suboptimal utilization of available vehicle capacity, which has contributed to increased operational costs (Hassan, 2021). On the other hand, Vehicle Route Mapping maximizes vehicle travel efficiency by selecting routes with the shortest possible distance, supporting reduced travel time and fuel consumption (Hsu, 2007). When applied together, these three methods complement each other and create significant opportunities for overall efficiency improvements.

The comparison results in Figure 3 and Table 13 show that the combination of these three methods yields far more significant results than the partial application of each method. By integrating Lean concepts through NVA analysis, truck loading capacity optimization, and vehicle route planning, PT. Sumarna successfully reduced the number of internal trucks required from 10 units to just 5 units. Additionally, the total daily truck rental hours also decreased, directly impacting the reduction in costs paid to third-party logistics partners (3PL). This efficiency contributed to a 47.15 percent of reduction in internal transportation operational costs, equivalent to USD 239,600 per year. These findings align with previous concepts in supply chain management and logistics literature, such as the Lean Thinking principles by Womack and Jones in 2003, which emphasize the importance of reducing waste to create value, as well as thoughts on the importance of efficiency and integration in logistics systems (Nikolova & Nterai, 2023).

Based on these findings, the study recommends the combination of these three methodologies be implemented sustainably in PT. Sumarna's internal logistics processes to maintain long-term efficiency. Additionally, the development of a real-time data-based monitoring system is suggested to periodically evaluate route performance and vehicle utilization (Shamsuzzoha *et al*., 2020). Training and capacity building for human resources in understanding and applying Lean Logistics principles are also strategic steps to support the sustainability of this efficiency (Knoll *et al*., 2019). Finally, this proven effective approach can also be replicated to evaluate logistics efficiency on a broader scale, such as inter-branch distribution or external logistics processes of the company (Ahmad *et al*., 2022).

CONCLUSION

This study found that the internal logistic process in PT. Sumarna has several waste that increases the cost. From NVA analysis, truck utilization time is considerably low with 56.2 percent of time utilization in average for each truck. According to fill rate analysis, the majority of PT. Sumarna's internal logistic trips are full, and multiple trips could be combined to cut down on the number of trips needed to move the finished goods and raw materials from the warehouses in Lot 17 (Warehouse Area) to the production facility in Lot 41, and vice versa. Vehicle route mapping also

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shows that PT. Sumarna's internal logistic process has 37 empty trips per day as a result of return trips made after transferring items from warehouse A to warehouse B and back to warehouse A, indicating process losses. In PT. Sumarna, the number of internal trucks may be decreased from 10 to 5 units by combining the LEAN methodology concept of NVA analysis, truck fill rate optimization, and vehicle route mapping. This results in cost productivity of 239.6 k USD annually. This is beyond the initial target of 165 k USD per annum stated by PT. Sumarna's board of director (152 percent of achievement).

This study has a number of limitations because it only looks at internal transportation movements that convey groupings of commodities with reasonably extended expiration dates and highly consistent dimensions. While a model or simulator will be needed for large numbers of vehicles requiring dynamic routes, the vehicle route mapping done in this study may accommodate non-massive vehicle numbers and static pre-registered routes. Volume fluctuation responses are likewise outside the purview of this investigation. As this vehicle route mapping is powerful to increase the efficiency of trips by evaluating the total mileage covered, a heavy exercise needs to be carried out to adjust with day to day dynamics. The development of tools to govern and aid such activity is crucial to maintain the accuracy and consistency of vehicle route mapping. Future research will be focused on the development of tools that can handle dynamic routes in order to respond to customer's requirement and volume volatility.

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