Analysis of Efficiency The Distribution Proces Using The Data Envelopment Analysis (DEA) Method and Lean Thinking Approach

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Abstract---The purpose of this study is to identify the causes of product distribution inefficiencies and determine the appropriate distribution process strategy using the Data Envelopment Analysis (DEA) Method and the Lean Thinking Approach. The DEA method is used to analyze efficiency values with specified input and output and the Lean Thinking Approach with VSM and VALSAT is used to analyze the factors that cause inefficiency and improve the distribution process. Factors that cause inefficiencies include: waiting for processed products from other divisions, the process of moving products, the process of re-inputting data when scanning products and interference with systems. The result of the Lean Thinking approach is to eliminate some processes that have no value added, reduce the lead time in the distribution process and apply the pull system strategy in the distribution process.

The calculation result of the DEA Model CCR Model, where the average value of efficiency in the distribution section in 2018 is 97.5% with only 1 month from 2018 which achieves an efficient value is August with recommendations for improvement reducing the input value in the distribution section. Lean Thinking approach uses VALSAT and VSM, for VALSAT with Process Activity Mapping with operations from the initial percentage of 76.62% increasing to 82.86%, while other activities namely transportation decreased from the original 7.79% to 3.83% inspection to by 3.23%, storage by 0% and delay decreased from 13.24% to 10.08%, for VSM the decrease in lead time from 200 minutes to 161 minutes. The Solution of the Lean Thinking Approach is to change layouts, implement pull systems in the distribution process and provide education and information to employees in product processing and product distribution in MPC, so that efficiency improvements can be achieved without having to reduce the input value of products distributed by the MPC distribution section, but the deepening of the application of recommendations for improvement must be explored in depth in terms of costs and broad impact on MPC.

Keywords---Metode DEA, Nilai Efisiensi, Lean Thinking.

I. INTRODUCTION

Distribution channels may or commonly called marketing outlets in principle is a series of organization that mutually dependent that is easy to over of ownership as products move from a producer to users business or customers [1]

The distribution of is an activity that is had a role in connecting the interests of the producer and the consumer , so that needs to be done in an efficient way to make it capable in obtained the advantages of which were proposional for producers. Formally,a distribution channel (channel of distribution) is a business structure of an interdependent organization that reaches from the starting point of a product to the customer with the aim of moving the product to the final consumption destination [2].

The research was done at one of the logistics service companies in Indonesia which is engaged in courier services, logistics, and financial transactions. PT X has 16 package processing central units spread throughout Indonesia, one of which is located in Bandung, namely the Central Processing Unit of the Mail Processing Center (MPC) 40400. The problem that occurs in the Mail Processing Center 40400 is the inefficient time of product distribution.

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The distribution process at the Mail Processing Center (MPC) Package Processing Unit is divided into 3 shifts: morning, afternoon and night, but the night shift is the highest busy shift because MPC starts shipping to its destination starting at the night shift. The average time of product distribution on the night shift for 1 month is 178 hours and the average time inefficiency is 29 hours

This study aims to analyze the level of product distribution efficiency and build a better system, using Data Envelopment Analysis (DEA) and the Lean Thinking approach. Data Envelopment Analysis (DEA) is an important tool that can be used to evaluate and improve the performance of a manufacturing or service business. DEA is widely applied in performance evaluation and benchmarking in educational institutions, hospitals, bank branches, production plans and others.

[3]. Data Envelopment Analysis (DEA) is a non-parametric approach which is basically a linear programming technique based on calculating the ratio of output and input ratios for all units compared (Susatyo et.el). The DEA method was created as a performance evaluation tool for an activity in an entity unit (organization), hereinafter referred to as the Decision Making Unit (DMU) ",(Dewi, S, Kusuma, 2015). While the concept of Lean Thinking is the concept of downsizing or efficiency. "This concept can be applied to manufacturing or service companies. The implementation of this concept is based on 5 main principles (Specify value, Identify whole value stream, Flow, Pulled, and Perfection)[6]

The relationship between the DEA method and the Lean Thinking concept are the two methods aimed at calculating the efficiency and effectiveness of a system, in this study the DEA method will focus on calculating the efficiency in the product distribution process, while the use of the Lean Thinking concept is used to increase the efficiency value of the calculation results of the method DEA The analysis starts from the waste / waste that causes inefficiency of time and failure in the distribution process, from the existing waste analysis researchers use Value Stream Mapping and VALSAT to eliminate waste in the distribution section and increase efficiency in the distribution section. The combination of these two methods is intended to produce optimal solutions and strategies for increasing the efficiency of product distribution in the distribution section of the Central Processing Package Mail Processing Center (MPC) 40400.

II. LITERATURE REVIEW

Data Envelopment Analysis

DEA is an operational research technique focused on measuring and analyzing the efficiency with which goods and services are produced. Its main applications have been in sectors such as finance, health, services, education or to measure the effectiveness of organizational indicators [7].

First introduced by Charnes, Cooper, and Rhodes (CCR) in 1978. this method does not require a production function and the results of its calculation are called relative efficiency values. So it can be said that DEA is a method not a model. DEA is a multifactorial analysis method to measure the efficiency and effectiveness of a group of homogenous Decision Making Units (DMU). The Efficiency Score for multiple outputs and inputs can be determined as follows:

$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}} \qquad (1)$$

Assuming n DMUs, each with n inputs and s outputs, the relative efficiency values   from the calculation of a DMU are obtained from the following model introduced by Charnes et al., As follows:

$$\max = \frac{\sum_{r=1}^{s} v_r y_r}{\sum_{i=1}^{m} u_i x_i} \tag{2}$$

$$s.t \frac{\sum_{r=1}^{s} v_r y_r}{\sum_{i=1}^{m} u_i x_i} \leq 1, \forall j \tag{3}$$

$$v_r, u_i \geq 0, \forall r, i \tag{4}$$

Where :

y = output variable r = 1 to s, (index for output)

x = input variable i = 1 to m, (index for input)

u = input weights j = 1 to n, (index for the number of DMUs)

v = output weight

The equation cannot be solved using a linear program, so it must be changed in a linear program like this:

$$\max imaze \sum_{r=1}^{s} v_r y_r \tag{5}$$

$$subject\ to \sum_{i=1}^{m} u_i X_i = 1 \tag{6}$$

$$\sum_{r=1}^{s} v_i Y_{rj} - \sum_{i=1}^{m} u_i X_{ij} \leq 0; j = 1, 2, 3, \dots n \tag{7}$$

$$v_r \geq 0; r = 1, 2, 3 \dots \dots, s \tag{8}$$

$$u_i \geq 0; i = 1, 2, 3 \dots \dots, m \tag{9}$$

The formula above is run n times on identifying the relative efficiency values   for all DMUs [8].

B. Lean Thinking

In general, lean concept is a streamlining concept and can be applied to manufacturing or service companies.

The concept of lean thinking began to be initiated by Toyota's production system in Japan. Lean was pioneered by Taichi Ohno and Sensei Shigeo Shingo where the implementation of this concept is based on 5 main principles, namely: Specify value, Identify whole value stream, Flow, Pulled and Perfection [9].

Lean thinking carries the concept of efficiency but still prioritizes effectiveness, because the main goal of lean thinking is to provide what customers want with the lowest possible cost, while lean production is a production system innovation that combines craft production with mass production [10]

Lean production basically aims to create products with many variations but still has a low cost. The lean concept was first present in Japanese companies. One of the companies from Japan is Toyota which is a reference model for implementing lean concepts. The popular definition of lean manufacturing and the Toyota Production System (TPS) is to be a complete technique when combined and mature, will help to reduce and then eliminate the seven types of waste [11]

Value Stream Mapping (VSM)

Value Stream Mapping is a process mapping tool that serves to identify the flow of material and information in the production process from materials to finished products [12]. Value Stream Mapping is a visual method for mapping and information from each work station [13].

Value Stream Mapping can be used as a starting point for companies to recognize waste and identify the cause, using Value Stream Mapping means starting with the big picture in solving problems not just in single processes and making improvements as a whole and not just in certain processes only. Value Stream Mapping is represented by symbols that represent activities. Where there are two activities namely value added and non value added. Value Stream Mapping is all activities (value added or non-value added) needed to make products through the main production process flow [10]

Value streams can describe activities such as product design, product flow, and flow of information that support these activities. Value Stream Mapping or also often known as Big Picture Mapping is a tool used to describe the whole system and the value stream that is in it. This tool describes the flow of material and information in a value stream.
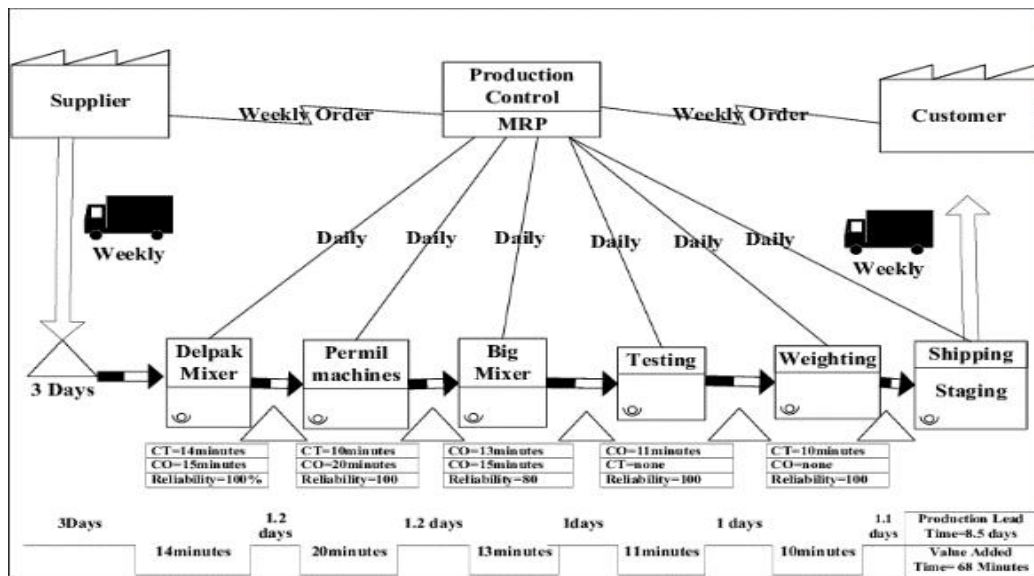

Figure 1: Example of VSM

Value Stream Analysis Tools (VALSAT) are used as a tool to map in detail the value stream that focuses on the value adding process. This detailed mapping can then be used to find the cause of the waste that occurs.

According to [9] there are seven types of detailed mapping tools that are most commonly used, as follows: Process Activity Mapping, Supply Chain Response Matrix, Production Variety Funnel, Quality Filter Mapping, Demand Amplification Mapping, Decision Point Analysis and Physical Structure. The use of the seven tools above is based on the right selection based on the condition of the company itself and is carried out using Value Stream Analysis Tools (VALSAT).

III. RESULTS and DISCUSSION

A. Results of Product Distribution Data at PT X

The initial step in this research is to determine the number of products that have been processed by PT X in the Central Processing Unit of the Mail Processing Center (MPC) 40400. The following results of data processing:

Table 1: Product Distribution Data at PT X

Month	Distributed (*unit*)	Distributed Failed (*unit*)	Total (*unit*)
Januari	103.329	2.588	105.917
Februari	89.402	4.601	94.003
March	106.509	5.976	112.485
April	123.530	4.015	127.545
Mei	119.814	3.917	123.731
June	83.661	3.693	87.354
July	113.814	3.430	117.244
August	112.607	2.348	114.955
September	117.71	7.386	119.157
Oktober	134.726	6.908	141.634
November	116.442	4.083	120.525
Desember	113.977	3.518	117.495

Total	1.329.582	52.463	1.382.045
Average	110.799	4.372	115.170

Table 1 is a combination of various types of products processed at PT X in the Central Processing Unit Mail Processing Center (MPC) 40400 B, such as: Express Post (PE), Special Express Mail (PKH), Ordinary Post Package (PPB) and Jumbo Express Package (PJE). While this data in the form of product distribution time in the distribution section which includes days and hours in 1 year is shown in table 2 follows :

Table 2: Product Distribution Time

Month	Working Days	Processing Time Standars	Real Processing Time
January	27	162	176
February	23	138	185
March	25	150	180
April	24	144	166
Mei	24	144	182
June	23	138	183
July	26	156	173
August	25	150	165
September	24	144	181
Oktober	27	162	179
November	25	150	178
Desember	25	150	184
Total	298	1.788	2.132

Month	Working Days	Processing Time Standars	Real Processing Time
Average	25	149	178

B. Initial Efficiency Value of Distribution Section

This processing is intended to determine the efficiency of the initial conditions in the distribution section, in this section the calculated efficiency value is the level of input and output on postal products that have been processed by the distribution. Input is the number of products received by the distribution department, Distributed is the product that was successfully sent by the distribution department, and failed to distribute is the number of products that were not successfully sent by the distribution department.

Table 3: Value of Product Distribution Efficiency at PT X

Month	Input (unit)	Distributed (unit)	Distributed Failed (unit)	Efficiency
January	105.917	103.329	2.588	97,56%
February	94.003	89.402	4.601	95,11%
March	112.485	106.509	5.976	94,69%
April	127.545	123.530	4.015	96,85%
Mei	123.731	119.814	3.917	96,83%
June	87.354	83.661	3.693	95,77%
July	117.244	113.814	3.430	97,07%
August	114.955	112.607	2.348	97,96%
September	119.157	112.717	7.386	93,80%
Oktober	141.634	134.726	6.908	95,12%
November	120.525	116.442	4.083	96,61%
Desember	117.495	113.977	3.518	97,01%
Total	1.382.045	1.329.582	52.463	-
Average	115.170	110.799	4.372	96,20%

Example Calculation:
1. Total Distributed:

Formula: $\sum$ Distributed per Month

= Distributed in January + Distributed in February + ... + Distributed in December

= 103,329 + 89,402 + 106,509 + ... + 113,977

= 1,329,582 Product units

2. Failed to be Distributed: Input - Distributed

Formula: nth Month Input - nth Month Distributed

a. Distributed Failure in January

January Inputs - Distributed in January

= 105,917 - 103,329

= 2588 Product units

b. Distributed Fail: February

February Input - Distributed February

= 94,003 - 89,042

= 4,601 Product units

c. Distributed Fail: March

February Input - Distributed February

= 112.485 - 106.509

= 5,976 Product unit

By using the formula in equation 2 then:

a. The Efficiency of month January

$$= \frac{\text{The amount of output weight ke - n}}{\text{The amount of input weight ke - n}} \qquad = \frac{103329}{105917} \times 100\% = 97,56\%$$

= The Efficiency of month February

$$= \frac{\text{The amount of output weight ke - n}}{\text{The amount of input weight ke - n}} \qquad = \frac{89042}{94003} \times 100\% = 95,11\%$$

b. The Efficiency of month March

$$= \frac{\text{The amount of output weight ke - n}}{\text{The amount of input weight ke - n}} \qquad = \frac{89042}{94003} \times 100\% = 95,11\%$$

After knowing the initial efficiency conditions, the results of calculations in the initial conditions will be used as input for the Data Envelopment Analysis (DEA) method. The model that will be used in the DEA method is the CCR (Charnes-Cooper-Rhodes) Model or often referred to as CRS (Constant Return to Scale).

C. Data Envelopment Analysis (DEA) CCR Model

Decision Making Unit (DMU) in this CCR model, for input data 1 the researcher uses the total number of distribution inputs in Table 4 and the distribution output data shown for each input and output are as follows: input 1 (unit) and for output (unit).

Table 4: Calculation Results of the CCR Model

DMU	Input 1	Output	Efficiency	Information
January	105.917	103.329	0,9959	Not Efficient
February	94.003	89.402	0,9708	Not Efficient
March	112.485	106.509	0,9662	Not Efficient
April	127.545	123.530	0,9887	Not Efficient
Mei	123.731	119.814	0,9885	Not Efficient
June	87.354	83.661	0,9769	Not Efficient
July	117.244	113.814	0,9909	Not Efficient
August	114.955	112.607	1	Efficient
September	119.157	117.710	0,9575	Not Efficient
Oktober	141.634	134.726	0,9710	Not Efficient
November	120.525	116.442	0,9862	Not Efficient
Desember	117.495	113.977	0,9920	Not Efficient

Based on table 4, the August DMU that produces an efficiency value = 1, while the other month < 1, so that the August efficiency will be used as a reference set to increase the efficiency value of other DMUs in order to achieve efficiency = 1

The following is a list of reference sets for each DMU

Using the formula in equation 2, then:

$<$ January $>$ max $\theta = \mu$

subject to $105917v_1 = 103329$

$\mu \leq 105917v_1$ (Januariy

$\mu \leq 94003v_1$ (February)

$\mu \leq 112485v_1$ (March)

$\mu \leq 127545v_1$ (April)

$\mu \leq 123731v_1$ (Mei)

$\mu \leq 87354v_1$ (June)

$\mu \leq 117244v_1$ (July)

$\mu \leq 114955v_1$ (August)

$\mu \leq 119157v_1$ (September)

$\mu \leq 141634v_1$ (Oktober)

$\mu \leq 120525v_1$ (November)

$\mu \leq 117495v_1$ (Desember)

Table 5: Reference Set DMU

DMU	x_1	y	Efficiency Score	Reference Set
January	105.917	103.329	0,9959	August
February	94003	89402	0,9708	August
March	112485	106509	0,9662	August
April	127545	123530	0,9887	August
Mei	123731	119814	0,9885	August
June	87354	83661	0,9769	August
July	117244	113814	0,9909	August
August	1149	1126	1	August

	55	07		
September	1191 57	1177 1	0,9575	August
Oktober	1416 34	1347 26	0,971	August
November	1205 25	1164 42	0,9862	August
Desember	1174 95	1139 77	0,992	August

The efficiency values of each DMU can be increased by adjusting the input or output values themselves depending on the orientation used first, after calculating using the DEA Solver add-ins on Microsoft Excel the following results are obtained to achieve the efficiency value = 1:

Table 6: Value of Repair Output (Unit)

DMU	*Input* 1	*Initial Output*	*Output* Repair
January	105.917	103.329	103.751,86
February	94.003	89.402	92.004,89
March	112.485	106.509	110.064,65
April	127.545	123.530	124.923,93
Mei	123.731	119.814	121.187,81
June	87.354	83.661	85.527,18
July	117.244	113.814	114.839,91
August	114.955	112.607	112.607
September	119.157	111.771	116.513,06
Oktober	141.634	134.726	138.624,87
November	120.525	116.442	118.040,96
Desember	117495	113.977	115.084,25

After completing the calculation using the DEA Method, the CCR Model can be concluded from the results of the DEA method that to achieve efficiency the output value must be increased to achieve the efficiency value itself, for January output values   originating from 103,329 to 103751.9 an increase of 0.41%. The DEA Method CCR Model calculation results will be used as a basis for the Lean Thinking approach, in the Lean Thinking approach the tools to be used are Value Stream Mapping (VSM) and Value Stream Analysis Tools (VALSAT) analysis. VSM is used to identify material and information flows in the product distribution process in the distribution and VALSAT Analysis tool to map in detail the value stream that focuses on the value adding process

D. Lean Thinking Analysis

For the next analysis was undertaken (waste), lean this is done to know the state of the cause of inefficiency in the process of the distribution of the product in MPC, the data waste be had from how to do an interview with 8 employees, distribution this was waste that was found on the distribution and recapitulation: interviews dan

Example Calculation:

Waiting: Total waiting score / Number of respondents

: 16/8 = 2

Transportation : Total transportation score / Number of respondents : 15/8 = 1,875

Table 7: Recapitulation 7 Waste

No.	*Waste*	Total	Score
1	*Overproduction*	0	0
2	*Waiting*	16	2
3	*Transportation*	15	1,875
4	*Rework*	11	1,375
5	*Inventory*	0	0
6	*Motion*	4	0,5
7	*Defect*	9	1,125
	Total Nilai	55	6,875

E. Value Stream Analysis Tools (VALSAT) Analysis

Following are the results of processing interviews with distribution employees using VALSAT which will be presented in Table 8 below:

Table 8 VALSAT

Waste	Activity Mapping	Mapping Chain Response	Production Variety Funnel	Filter Mapping	Amplification Mapping	Point Analysis Decision	Structure
Overproduction							
Waiting	H	M	M				M
Transportation	M	M	L				M
Rework	H	L	M	M			L
Inventory							
Motion	L						
Defect	L		L				

In this VALSAT there are seven tools that will later be used to analyze these wastes. Value stream mapping with the largest total score according to the results of VALSAT will be selected mapping to be able to identify waste in detail. This selection is based on that value stream mapping with the largest value is most suitable for identifying waste in the value stream. The complete results of VALSAT can be seen in table 9 below

Table 9: Recapitulation of VALSAT Calculation

Waste	Process Activity Mapping	Supply Chain Response Matrix	Production Variety Funnel	Quality Filter Mapping	Demand Amplification Mapping	Decision Point Analysis	Physical Structure
Overproduction							
Waiting	18	6	6				6
Transportation	5,62	5,6	1,8				5,6
Rework	12,37	1,3	4,12	4,12			1,3
Inventory	0,5						
Motion	1,12		1,1				

Defect	37,6	13	13,1	4,1	0	0	13
Total	1	3	2	4	5	5	3
Ranking							

Where :

H = (High Coleration and usefulness)

High usability and correlation multipliers = 9

M = (Medium coleration and usefulness)

The use and the moderate correlation factor = 3

L = (Low correlation and usefulness)

Low usability and correlation multipliers = 1

Process Activity Mapping - Waiting ¬: Waiting Weight x multiplier factor: 2 x 9 = 18

Process Activity Mapping - Rework: Weight Rework x multiplier factor

: 1,375 x 9 = 12,375

In accordance with the table above it can be seen that the tool chosen in the largest score order is Process Activity Mapping with a total score of 37.62. This Activity Mapping process will be used as a tool to analyze activities in the distribution section.

Process Activity Mapping (PAM) maps the process in detail step by step, following the analysis of the PAM tool This process uses symbols that represent operations activities with the symbol O, transportation with the symbol T, inspection with the symbol I, storage with the symbol S, and delay with the symbol D. The following is a recapitulation table of Process Activity Mapping:

Table10: Recatulation of Activity Mapping

No.	Type of Activity	Amount	Presentage (%)
1	*Operation*	17	56,67
2	*Transportation*	4	10
3	*Inspection*	3	10
4	*Storage*	0	0
5	*Delay*	7	23,33
	Total	30	100

Table 10 shows that operating activities including value adding activity had a percentage of 56.67%, while other activities were transportation by 10%, inspection by 10%, storage by 0% and delay by 23.33%. The activities in PAM will be discussed in more detail in the following table of working time in PAM:

Table 11:Total Working Time in PAM

No.	Type of Activity	Time (Minute)	Presentage (%)
1	*Operation*	260.5	76,62
2	*Transportation*	26.5	7,79
3	*Inspection*	8	2,35
4	*Storage*	0	0
5	*Delay*	45	13,24
	Total	340	100

Table 11 shows that operating time including value adding activity has a percentage of 76.62%, while other activities are transportation by 7.79%, inspection by 2.35%, storage by 0% and delay by 13.24%, by Therefore, to support the smooth running of the distribution process, activities that are included in the non-value adding activity must be reduced. The amount and percentage of time for each type of activity in the process activity mapping (PAM) proposed improvement can be seen in table 12 belows:

Tabel 12: Recapitulation *Activity Mapping*

No.	Type of Activity	Amount	Presentage (%)
1	*Operation*	17	58,62
2	*Transportation*	4	10,34
3	*Inspection*	3	10,34
4	*Storage*	0	0
5	*Delay*	6	20,69
	Total	29	100

Table 12 shows the changes in the proposed improvement, the percentage of operating activities which had an initial percentage of 56.57% to 58.62%, while other activities namely transportation by 10.34% even though the level of transportation increased but transportation time decreased, inspection increased 7, 99% to 10.34%, storage by 0% and delay by 20.69% with a decrease of 2.64% and the number of activities from 7 activities to 6 activity delays.

Table 13: Total Working Time in PAM

No.	Type of Activity	Amount	Presentage (%)
1	*Operation*	205,5	82,86
2	*Transportation*	9,5	3,83
3	*Inspection*	8	3,23
4	*Storage*	0	0
5	*Delay*	25	10,08
	Total	248	100

Table 13 shows that the operation time decreased from 260.5 minutes to 205.5 minutes and had an initial percentage of 76.62% increasing to 82.86%, while other activities namely transportation decreased from the original 7.79% to 3.83% with a decrease in time of 64.15% from 26.5 minutes to 9.5 minutes, inspection to 3.23%, storage by 0% and delay decreased from 13.24% to 10.08%, therefore, with decreasing transportation and delay will speed up the distribution process in the distribution department

IV. CONCLUSION

Based on the results of research in the distribution of PT X in the Central Unit Processing Mail Package Center (MPC) 40400 it can be concluded that the increase in efficiency in the distribution can be done by using the DEA Mode CCR Method and the Lean Thinking Approach. The results of both methods are reducing input (DEA Method) and improving layout and educating employees (Lean Thinking) but analysis must be carried out both in terms of cost and impact. The following results from the DEA Method and the Lean Thinking Approach:

1. The average efficiency value in the distribution section is 0.976 with the lowest contributors to the efficiency value of the last 4 months namely: September, October, November and December and suggestions for achieving efficiency values The DEA Method CCR Model can be used to increase output.

2. Increasing the value of product distribution efficiency in the distribution section according to the lean thinking approach can be achieved based on the results of VALSAT by improving layout, education as well as information on employees in the product processing and product distribution section at MPC, and eliminating some processes that are considered to have no added value.

3. Reduction of lead time from 200 minutes to 161 minutes using recommendations for improvement from VALSAT is applied to the value stream mapping, although there are still activities that are non value added.

4. Increasing the value of efficiency can be achieved without having to reduce the input of products owned by MPC Bandung, by changing the layout and education as well as information on employees in the product processing and product distribution at MPC can increase the value of efficiency.

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