Productivity Analysis in Assembly Department Using Objective Matrix (Omax) Method in Labor Intensive Manufacturing

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ABSTRACT

Productivity has become a holistic target in any manufacturing company. Performance evaluation for production areas in manufacturing should be measure by productivity index that already determined in company goals and targets. Currently, the productivity index has been measured by simple calculation, which only considering production result, manpower and working hours. Those calculations still cannot meet management desire about real productivity itself. Management needs productivity also considering some other performance, those are including quality rate, rework rate, manpower, working hour, production result, energy usage, and compliance with the schedule as input. This desire was mentioned in a company mission to be world-class manufacturing. A well-known method as an objective matrix would be used for measuring the productivity index in the company. There would be a different rank of productivity after considering all of the mentioned items when compared with the currently used method. Production could be bigger than other month but on the other hand quality rate and rework, the rate was dropped. Than rank for productivity index in this company would be more complex and could be used as a raw model of productivity measurement internally or externally.

*Key Words***: Productivity, Performance, Objective Matrix (OMAX), Productivity Index.*

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1. INTRODUCTION

Shoe manufacturing in Indonesia is growing rapidly, especially for export oriented item. Indonesia has become one of targeted country by investors to invest in shoe manufacturing. Some of the contributing factors are low labor cost and product quality or craftsmanship. Although labor the cost is low, but buyer or customer only paid by unit price. To get low unit price there would be labor cost and material need to be monitored. Indonesian labor productivity is still low compared with China and Vietnam as competitors.

It is known that shoe manufacturer would need speed, quality and prices which will be an indicator of the company being able to excel in the competition within next few years. In order to be more competitive in global market, all shoe manufacturers in Indonesia must be able to provide customer satisfaction as reflected by faster lead times, cheaper prices and higher quality.

PT. PIN, as one of shoe manufacturer, which engage in producing branded shoe from US. The company are trying to compete as number one in Indonesia and getting the best performance manufacturer for that brand in the world. There are 42 other company over the world are producing this brand and 14 are in Indonesia. Management consider about several thing that can make this company to compete with other company over the world. They are productivity, quality and cost which came from internal company itself. One of the main indicators in assessing a company's competitive ability is to measure productivity [1][2]. The results of the study from Heizer and Render (2006)[3], define that there are several methods that can be used to measure productivity, but it would be difficult to get accurate result, therefore approach methods are usually done to measure productivity.

Productivity measurement with only one resource as an input to measure productivity is known as single-factor productivity. Heizer and Render (2006)[3] explained that multifactor productivity would consider man, material, energy, management and capital. Currently PT. PIN measures productivity using single factor as resources. With management objective there would be several input needed to measure productivity, which could impact to cost and quality. The lack of constrains to getting productivity on the production floor was generally influenced by factors of non- confirming resource used during production activity [4] To improve the result to appropriate measurement, it should be measures by Objective Matrix (OMAX) method [5].

The objective of this study is to compare which is more representative for productivity measurement between single factor that used by company or multifactor productivity using OMAX method. With this measurement management could decide which is best to use in the company in the future as internal measurement.

2. LITERATURE SURVEY

Productivity relates to the effectiveness and efficiency of utilization of resources (inputs) in producing the output [6]. Company emphasizes on production operations by maintaining the quality of the products produced, which can increase productivity by improving production by analyzing production results in each production process [7].

The production factors in input are men, money, machines, materials, methods and environment, which affected to the flow of the production process in gaining to quality of product [8]. Objective Matrix (OMAX) was developed by James L. Riggs PE in the 80' in the US. OMAX methodology measures productivity by evaluating achievements in each part of company [5]

OMAX productivity has traditionally been defined as ratio between output an input [9]. OMAX itself tend to performance measurement method that evaluate several criteria by weighting to get overall enterprise productivity index [5]. There are several study using the same method and mentioning before having wighting it should be decide for degree of importance of all criteria by using Analytical Hierarchy Process [10]. Analytical Hierarchy Process (AHP) could be determined by using questionnaires to respective stakeholder and management [10]. By calculating final score and simplify benchmark with previous productivity score as current comparison to determine productivity of increase or decrease [11].

OMAX have a very unique characteristic, such as work group's performance criteria is combined in one matrix. Each criterion has a target in the form of a special repairing path menu and the weights would depend on each productivity level. The final result of this assessment is single value for work groups. According to James L Rigss in Balkan's (2010)[9], there are some step to do this method as below;

1. Determine measurement goals.Setting goals for measurement is the first step which must be determined before committing research.
2. Determine the measurement criteria
3. Determine the performance ratio. Performance is ratio of productivity level from each measurement criterion. Performance value would be obtained by dividing the ratio input with output on each criterion.
4. Determine target. This could be gathered from company objective or goals to increase 30% from each productivity ratio in the company.
5. Determine realistic productivity value (score 1-2 and Score 4-9). This could be calculated using interpolation method. According to Balkan (2011)[8], Equation would be as (1) and (2) below :

$$Interval_{0\sim3} = \frac{Score\ 3 - Score\ 0}{3\text{-}0} \qquad \text{------------} \quad (1)$$

$$Interval_{3\sim10} = \frac{Score\ 10 - Score\ 3}{10\text{-}3} \qquad \text{-----------} \quad (2)$$

6. *Determine criteria weighting value. This could be emphasized by determining which criteria are more important than other. To make it easier, a conversion table needs to be made from priority* statement to numbers as table 1 below [9].

Table 1. Criteria Priority Level

Value	Priority Degree
1	Criteria 1 same important as Criteria 2
3	Criteria 1 little bit more important from Criteria 2
5	Criteria 1 more important from Criteria 2
7	Criteria 1 very important compare to Criteria 2
9	Criteria 1 extremely more important from Criteria 2
2,4,6,8	Value between above.

7. Determine score of the scale.
   a. Score is level which shows the existence of productivity measurement value.

  b. Weight is value of each productivity criterion against total productivity. This determined by processing the data obtained from questionnaires in AHP method.

  c. Value is the result of multiplication between scores and weights on the measured criteria.

8. Determine Productivity Index Total.

3. OBJECTIVE OF THE STUDY

The objective of this study is to compare productivity measurement between single factor that used by company with multi factor productivity measurement using OMAX method. With this measurement, the management would decide the best method of performing the task for internal measurement.

4. RESEARCH METHODOLOGY

The research was done using primary data and secondary data. Primary data is the data obtained from field such as observation in production area, interviews with management and AHP questionnaire data. Secondary data has been gathered from company data such as company profile, production result data, man power data, working hour data, energy consumption data, rejected rate data and schedule data. There are some steps need to be done for this research as figure 1 below.
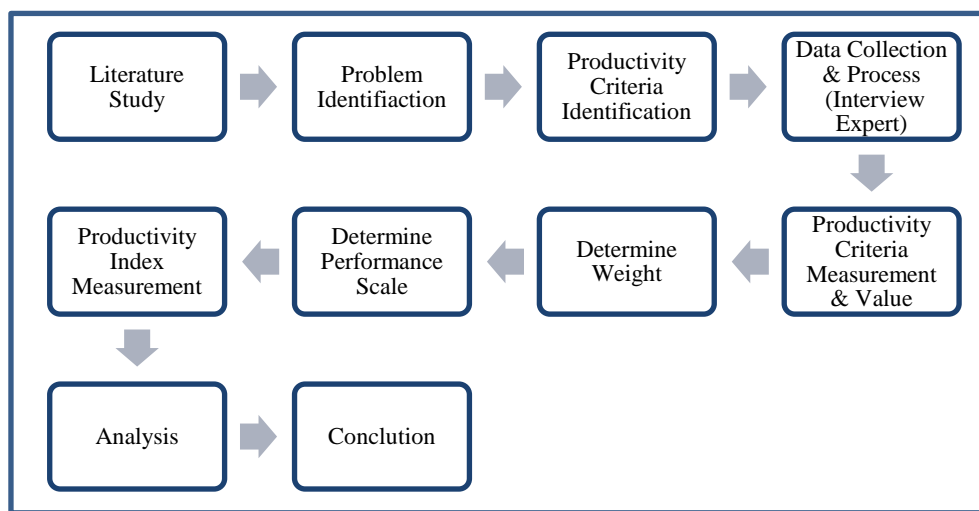

Figure 1 Research Flow Diagram

In the first step, there is discussion with management in PT. PIN to decide criteria of productivity need to measure. Management is deciding the criteria based on company goals for 2019 – 2020, which going to improve those criteria about 10%. This target also would be used as score 10 latter on. After decide which criteria than we gather data from Internal Auditor Department. The next would be calculation of each productivity criteria by dividing output with input. Each of criteria/ ratio would be weighting by distributing questionnaire to management level in the company. There are 10 management whom expertise in each area from production, manufacturing optimization, production planning, development, human resources, industrial engineering, internal auditors, quality, material and chemical engineers. Data that being used for the research could be shown as table 2 below.

Table 2 Data For Research.

No	Item	Explanation
1.	Production Result (pairs)	The result of shoe produced in pairs
2.	Working Hour (hours)	Working hour usage to produce above result
3.	Manpower (person)	Manpower usage to produce above result
4.	Production Plan (pairs)	How many shoe was produced as plan
5.	Defect Data (pairs)	How many defected shoe in one periods
6.	Rework Data (pairs)	How many reworks was done in one periods
7.	Energy Usage (KWh)	Energy consumption data using by production line.

In the discussion there are data for currently Productivity calculation and indicators used by company to analyze which month of the year has the best productivity ever in table 3.

Table 3. Company Productivity Calculation

2018	Prod Output	Work Hour	Man Power	PPH
JAN	1,541,291	190.01	20,395	0.40
FEB	1,252,175	176.19	20,185	0.35
MAR	1,322,578	190.17	19,601	0.35
APR	1,351,390	190.58	19,470	0.36
MAY	1,330,620	183.90	19,412	0.37
JUN	961,923	134.44	19,607	0.36
JUL	1,379,560	203.96	19,803	0.34
AUG	1,320,741	195.07	20,429	0.33
SEP	1,234,667	172.99	20,863	0.34
OCT	1,453,258	198.10	21,102	0.35
NOV	1,355,881	182.62	21,417	0.35
DEC	1,388,656	182.61	21,578	0.35

4. RESULT AND DISCUSSION

There is some step need to follow as mentioned in method.

1. Objective or the research is to comparing currently use productivity measurement method by company which using single factor with OMAX methodology which known as multifactor method.
2. Determine Ratio
   There are 6 criteria/ ratio going to measure as below:
   - a. Ratio 1 would be production optimization
   - b. Ratio 2 would be energy usage efficiency
   - c. Ratio 3 would be manpower usage efficiency
   - d. Ratio 4 would be production plan optimization
   - e. Ratio 5 would be product defect minimization.
   - f. Ratio 6 would be rework minimization.

All above ratio would be measured using equation in table 4.

Table 4. Calculation Of Each Ratio

No	Ratio	Calculation Method
1	Production Optimization	$\dfrac{\text{Production Result}}{\text{Working Hour Usage}}$
2	Energy Usage Efficiency	$\dfrac{\text{Energy Usage}}{\text{Production Result}}$
3	Manpower Usage Efficiency	$\dfrac{\text{Production Result}}{\text{Working Hour x Man Power}}$
4	Production Plan Optimization	$\dfrac{\text{Prod. Result as Planned}}{\text{Production Result}} \times 100\%$
5	Product Defect Minimization	$\dfrac{\text{Product Defect}}{\text{Production Result}} \times 100\%$
6	Rework Minimization	$\dfrac{\text{Rework Product}}{\text{Production Result}} \times 100\%$

3. Questionnaire step 1, to decide each ratio importance level. This was gathered by questionnaire distributed to management as table 5 mentioned.

Table 5. Questionnaire 1 Result

Ratio	Resp1	Resp2	Resp3	Resp4	Resp5	Resp6	Rata2	Rank
1	5	5	4	5	4	4	4.50	2
2	5	4	4	3	4	5	4.17	3
3	5	4	5	4	5	5	4.67	1
4	5	3	5	3	3	3	3.67	4
5	5	4	3	4	3	3	3.67	5
6	3	2	2	3	2	3	2.50	6

4. Questionnaire step 2, to decide level of intensity degree. This was gathered by using AHP method mentioned in methodology before in table 1 as priority criteria level.
5. After that matrix pairwise was made using information gathered from AHP questionnaire. Result could be shown in table 6.

Table 6. Weighting Matrix

	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5	Ratio 6	Sum	Weight
Ratio 1	6.00	11.67	4.42	18.83	33.33	57.67	131.92	25.55
Ratio 2	3.62	6.00	2.71	9.50	21.27	35.92	79.01	15.30
Ratio 3	10.47	21.33	6.00	31.25	52.00	73.00	194.05	37.59
Ratio 4	3.13	5.33	2.49	6.00	12.47	31.92	61.34	11.88
Ratio 5	2.34	4.02	1.71	4.35	6.00	14.25	32.67	6.33
Ratio 6	1.23	2.22	0.66	2.95	4.20	6.00	17.26	3.34
						Total	516.25	100.00

6. With table 5 result, than the rank of each ratio would be as below :
   - Rank 1 = Ratio 3 with 37.59 point weight
   - Rank 2 = Ratio 1 with 25.55 point weight
   - Rank 3 = Ratio 2 with 15.30 point weight
   - Rank 4 = Ratio 4 with 11.88 point weight
   - Rank 5 = Ratio 5 with 6.33 point weight
   - Rank 6 = Ratio 6 with 3.34 point weight
7. After calculation of Rank, than need to decide of target value, minimum value, and maximum value of each ratio. It could be shown in table 7 below.

Table 7. Standard, Target And Minimum Value

Ratio	Minimum Value	Standard Value	Target Value	Weight
Ratio 1	6,764	7,391	8,923	25.55
Ratio 2	3.893	3.640	2.853	15.30
Ratio 3	0.331	0.368	0.437	37.59
Ratio 4	41	52.04	67.34	11.88
Ratio 5	0.215	0.072	0.054	6.33
Ratio 6	33.09	17.01	14.75	3.34

8. With interpolation calculation the scale of each ratio would be as table 8 which calculate January productivity performance

Table 8. January 2018 Weighting Score

Rasio	Rasio 1	Rasio 2	Rasio 3	Rasio 4	Rasio 5	Rasio 6	Score
Actual Result	8,111	3.69	0.40	61.0	0.084	16.39	
Target	8,923	2.85	0.44	67.3	0.054	14.75	10
	8,704	2.97	0.43	65.2	0.057	15.08	9
	8,485	3.08	0.42	63.0	0.059	15.40	8
	8,266	3.19	0.41	60.8	0.061	15.72	7
	8,047	3.30	0.40	58.6	0.063	16.04	6
	7,829	3.42	0.39	56.4	0.066	16.36	5
	7,610	3.53	0.38	54.2	0.068	16.68	4
	7,391	3.64	0.37	52.0	0.070	17.00	3
	7,182	3.72	0.36	48.2	0.118	22.36	2
	6,973	3.81	0.34	44.4	0.167	27.72	1
	6,764	3.89	0.33	40.6	0.215	33.09	0
Aktual Score	6	2	6	7	3	5	
Weight	25.55	15.30	37.59	11.88	6.33	3.34	
Productivity	153.32	30.61	225.53	83.17	18.99	16.72	

| Productivity Index	528.33

9. Last step of OMAX method would be calculating Performance Index. The value would be obtained by comparing productivity index of current period with previous period. Performance index value before Januari 2018 would be called base period, than it's decide that period is considered as standard performance which means the score is located at level 3 and the value should be 300 point.

Table 9. Performance Index

Bulan	Nilai Indeks Produktivitas	Performance Index
Jan	528.33	76.11%
Feb	280.90	-46.83%
Mar	119.35	-57.51%
Apr	199.50	67.16%
May	293.25	46.99%
Jun	285.06	-2.79%
Jul	123.35	-56.73%
Aug	76.52	-37.96%
Sep	116.66	52.44%
Oct	280.00	140.03%
Nov	252.30	-9.89%
Dec	238.71	-5.39%

In the figure 2 there are performance index graph which showing the changes in productivity in every month
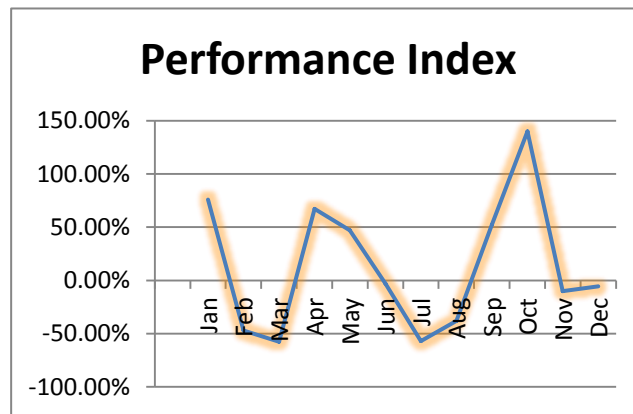
The ratio than identified with traffic light system, this is to find out how many ratio have below standar value. It is calculated by how many time it ocure in one year. Table 10 shows traffic light system for productivity ratio.

Table 10. Traffic Light System

Bulan	Rasio					
	1	2	3	4	5	6
Jan	6	2	6	7	3	5
Feb	2	5	2	2	7	3
Mar	1	1	1	1	3	3
Apr	1	4	2	1	3	2
May	2	6	3	1	3	2
Jun	2	7	2	3	2	1
Jul	0	4	1	1	2	0
Aug	0	5	0	0	0	0
Sep	2	1	1	0	2	0
Oct	3	5	2	3	2	1
Nov	3	2	2	4	3	1
Dec	4	0	2	3	3	2
Sum Red	8	5	10	7	5	9

Note :

- Green stands to perfromance has reach target
- Yellow stands to performance has not reach target but has approached the target
- Red stands for performance is below target and standard.

To analyze which ratio need tobe improves, need to calculate which ratio if often below standard, than multiply by weight of each ratio as describe in table 11.

Table 11. Ratio Below Standard

Ratio	Weight	Sum Red	Value	Accum %
Ratio 3	37.59	10	376	47%
Ratio 1	25.55	8	204	72%
Ratio 4	11.88	7	83	83%
Ratio 2	15.30	5	77	92%
Ratio 5	6.33	5	32	96%
Ratio 6	3.34	9	30	100%

Ratio 3, should be the key of all productivity performance. Ratio 3 stands for manpower usage efficiency which already use by company to measure productivity without considering other input. Ratio 1 also become 2nd key because relation of production output. Than Ratio 4 has become important due to impact of unplanned product produce by production would possibly causing other supply chain can't meet the requirement.

5. CONCLUSION

Comparison of 2 method of productivity calculation can be shown in table 12. There are six month of both calculation has the same rank, those are Jan as rank 1, May as rank 2, June as rank 3, August as rank 12, September as rank 11 and December as rank 7.

Table 12. Comparison Of Productivity Calculation

Month	Comp. Rank	PPH	OMAX Rank	PI
Jan	1	0.398	1	528.33
Feb	6	0.352	4	280.90
Mar	5	0.355	10	119.35
Apr	4	0.364	8	199.50
May	2	0.373	2	293.25
Jun	3	0.365	3	285.06
Jul	10	0.342	9	123.35
Aug	12	0.331	12	76.52
Sep	11	0.342	11	116.66
Oct	8	0.348	5	280.00
Nov	9	0.347	6	252.30
Dec	7	0.352	7	238.71

Differences in February, March, April, July, October and November because in OMAX calculation productivity was influenced by other variable such as production plan, energy, riject rate and rework in production.

OMAX method would be able to measure productivity partially on the production line. When OMAX used in partially it will find detail criteria which affecting the productivity level. For further research there is some possibility to include another variable in production such as product difficulties, product variation and type, waste released and machine downtime.

ACKNOWLEDGMENT

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