Measurement and analysis of productivity in the process of raw material shearing sheet by using matrix objective

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Abstract. One improvement that can be done is to increase the productivity of the company. Important productivity measurement and analysis was conducted to determine the level of efficiency and effectiveness of resource use. These measurements were done on the Raw Materials Inventory at Raw Materials Shearing process. By measuring the productivity of companies can see achievements that have been achieved and as a basis for planning and improvement of section Raw Materials Inventory. Productivity measurement is done using methods Objective Matrix (OMAX) and Cause and Effect Analysis. January to December 2019 fluctuated productivity. The increase in productivity index in the period from February, April, June, September, and November 2018. While the decline in productivity index occurred in January, March, May, July, August, October, and December 2019. Increased productivity is the highest in the period of November 2019, by performance indicator value of 1.49 and the lowest productivity decline in the period of August 2019, with a value of 0.60. And performance indicator criteria that need to be improved to achieve better productivity is the criteria one, three and four, the criteria Raw material shearing, shearing time, and the result of shearing.

Keywords: methods OMAX, raw materials shearing, cause and effect analysis

1. Introduction
Objective Matrix (Omax) is the method of measurement use to monitor productivity in the company. Measuring with use Omax having an excess on the data. The level of the interests of all the company has objective criteria and flexible to measuring [1]. PT. Fuji Technica Indonesia joined in Group 3 Astra Motor is a manufacturer of automotive components, especially relating to the press / stamping and assembling welding. Products produced by PT Fuji Technica Indonesia in supply to several automotive companies in Indonesia such as PT. Isuzu Astra Motor Indonesia, PT. Astra Daihatsu Motor, PT. Nissan Motor Indonesia, PT. Suzuki Indomobil Motor and PT. Honda Prospect Motor. Industrial stamping and assembling welding on the car has a fairly strong competitiveness because demand for cars growing all the time as well as the stamping process is a process that must be done in car manufacture. To achieve the production system more effective and efficient the whole firm in Astra Motor group to implement a program to achieve sustainable improvements for example Lean manufacturing, Kaizen, and so forth. Currently, PT. Fuji Technica Indonesia has implemented 5S program (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) and kaizen (continuous improvement) [2].
2. Literature review
The main objective measurement of data uniformity test is to obtain uniform data. Non uniform data can come without realizing it, we need a measurement to detect it. Control limits are established from the data whether or not a uniform boundary data. Uniformity test data needs to be done prior to using the data obtained [3].

2.1 Adequacy test data
The level of accuracy and the level of confidence is a reflection of the level of certainty desired by the gauge. The level of accuracy of forecasting results show the maximum deviation of the actual data. The confidence level indicates the magnitude of the measuring confidence that the results obtained are eligible thoroughness. Test the adequacy of the data is done by considering the level of confidence and accuracy required in accordance with the formula [3].

2.2 Objective matrix
Method of measuring productivity in the enterprise, one of which is method of Objective Matrix (Omax). Measurements on the model Omax developed by James L. Riggs at Oregon State University. Omax combining the criteria of productivity in the form of integrated and related to each other. excess methods Objective Matrix in measuring productivity is relatively simple and easy to understand, easy to implement and does not require any special skills, and the data is easily obtainable [4].

Omax is a method of evaluating the performance measurement criteria for productivity with weight gain overall productivity index. This model proposes the development of productivity at the level of activity. Method of Omax is important for ease of application. This method is also useful for projects and service functions are difficult to measure productivity [5].

This model has a unique characteristic, namely the work group performance criteria are combined in a matrix. Each criterion has a target in the form of a special line repair menu and has a weight in order of importance to the objectives of productivity. The end result of this evaluation is a single value for the working group [6]. Processing the data using a method developed by James L. Riggs has the following stages [5]

Determining Targets End (Score 10). The value of a score of 10 obtained from the Upper Control Limit (UCL) which is the limit of the maximum possible productivity achieved by the company of each criterion of productivity. UCL formula, Degree of Accuracy (DA), and Confident Level (CL) is following equation 1-3.

\[
UCL = \mu + k \cdot \sigma \quad (k = 2 \text{ for CL } \leq 95\%) \\
DA = \frac{\sigma}{\mu} \times 100 \\
CL = 100\% - DA
\]

Where:

\( \mu \): On average each criterion is measured.
\( \sigma \): Standard deviation.
\( k \): Constants.
\( k \): 1, if the confidence level (CL) is located at 0\% \leq 68\% \leq CL.
\( k \): 2, if the confidence level (CL) is located at 68\% <CL \leq 68\%.
\( k \): 3, if the confidence level (CL) is located at 95\% <CL \leq 99.7\%.

2.2.1 Determining the value of productivity realistic (Score Score 1-2 and 4-9)
Realistic productivity value is the value that could be achieved before the end goal. A score of 1-2 and 4-9 scores obtained from the interpolation. Interpolation formula used is based on Balkan [5].
interval 0-3 : \( \frac{\text{score 3} - \text{score 0}}{3 - 0} \)
interval 3-10 : \( \frac{\text{score 10} - \text{score 3}}{10 - 3} \)

2.2.2 Determining the weight value criteria
Determine the weight of each criterion emphasized in determining priority criteria by comparing the value of which is more important between criteria. To further facilitate the prioritization is needed to set the conversion table of priorities requests into figures. Table 1 shows the priority criteria used [4].

| Score | Priority Level |
|-------|---------------|
| 1     | CRITERIA 1 is as important as CRITERIA 2 |
| 3     | CRITERIA 1 is slightly more important than CRITERIA 2 |
| 5     | CRITERIA 1 is more important as CRITERIA 4 |
| 7     | CRITERIA 1 is very important compared to CRITERIA 5 |
| 9     | CRITERIA 1 is far more important than CRITERIA 6 |
| 2,4,6,8 | CRITERIA 1 (*) middle value |

3. Methods of cause and effect and fishbone diagram
There are many methods to determine the root cause of the problems that arise in the company, i.e.

- a. Brainstorming
- b. Ask why so many times
- c. Fishbone Diagram / Cause and Effect/ Ishikawa
  Fishbone diagram is one method / tool in improving quality. This diagram is commonly called as the Cause and Effect diagram or cause effect diagram. The inventor is a Japanese scientist in the '60s i.e. Dr. Kaoru Ishikawa Thus this diagram is also often called as the Ishikawa diagram. The method initially used more for quality management. Which uses verbal data (non-numerical) or qualitative data. Dr. Ishikawa also considered as the first to introduce 7 tools or quality control methods (7 tools). Namely fishbone diagram, control charts, run charts, histograms, scatter diagrams, Pareto charts, and a flowchart [7].
- d. Performance ratio
  Performance value shows the value of the four criteria in uniformity and adequacy of test data. So the data will be calculated and if it had been uniformly and fairly. The data of values for performance of each criterion can be seen in Table 2.

| Month | RM Shearing (sheet) | K1=X² | MP Shearing (person) | K2=X² | Shearing Time RM (minute) | K3=X² | Shearing results (pcs) | K4=X² |
|-------|---------------------|-------|----------------------|-------|--------------------------|-------|------------------------|-------|
| 1     | 3,210               | 10,304,100 | 3 | 9 | 1,070 | 1,144,900 | 6,420 | 41,216,400 |
| 2     | 2,550               | 6,502,500 | 3 | 9 | 850 | 722,500 | 5,100 | 26,010,000 |
This stage is processing the data to the four criteria to find the target end (score of 10), the target of a short (score 3), and the target of the worst (score of 0). Data processing to the four criteria are as follows:

1. **Targets End (Score 10)**
   \[ \sigma = 445 \text{ and } \mu = 3215 \]
   The level of accuracy
   \[ DA = \frac{\Sigma}{\mu} \times 100\% \]
   \[ = \left(\frac{445}{3215}\right) \times 100\% \]
   \[ = 0.1384 \times 100\% \]
   \[ = 13.84\% \]
   The confidence level
   \[ CL = 100\% - DA \]
   \[ = 100\% - 13.84\% \]
   \[ = 86.16\% \]
   BKA = \mu + k \times \sigma (k = 2 for CL \leq 95%)
   \[ = 3215 + 2 \times 445 \]
   \[ = 3215 + 890 \]
   \[ = 4105 \]
   K value is 1, when the value of CL is at 0% \leq CL \leq 68%; worth 2, when the value lies in the 68% CL <CL \leq 95%; and k is worth 3, when the value lies in the 95% CL <CL \leq 99%.

2. **Short-term targets (Score 3)**
   \[ \mu = \frac{1}{12} \sum_{i=1}^{12} X_i \]
   \[ = 3215 \]

3. **Targets worst (Score 0)**
   \[ \sigma = 445 \text{ and } \mu = 3215 \]
   BKB = M - k \times \sigma (k = 2 for CL \leq 95%)
   \[ = 3215 - (2 \times 445) \]
   \[ = 3215 - 890 \]

\[ \sum X^2 = 126,754,052 \quad \text{Average} \quad 3,224 \quad \text{Std. dev.} \quad 0.29 \]

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 3 | 3,190 | 10,176,100 | 3 | 9 | 1,063 | 1,129,969 | 6,380 | 40,704,400 |
| 4 | 3,310 | 10,956,100 | 3 | 9 | 1,103 | 1,216,609 | 6,620 | 43,824,400 |
| 5 | 3,170 | 10,048,900 | 3 | 9 | 1,057 | 1,117,249 | 6,340 | 40,195,600 |
| 6 | 3,300 | 10,890,000 | 3 | 9 | 1,100 | 1,210,000 | 6,600 | 43,560,000 |
| 7 | 3,890 | 15,132,100 | 3 | 9 | 1,297 | 1,682,209 | 7,780 | 60,528,400 |
| 8 | 3,170 | 10,048,900 | 3 | 9 | 1,057 | 1,117,249 | 6,340 | 40,195,600 |
| 9 | 2,896 | 8,386,816 | 3 | 9 | 965 | 931,225 | 5,792 | 33,547,264 |
| 10 | 3,190 | 10,176,100 | 3 | 9 | 1,063 | 1,129,969 | 6,380 | 40,704,400 |
| 11 | 4,100 | 16,810,000 | 3 | 9 | 1,367 | 1,868,689 | 8,200 | 67,240,000 |
| 12 | 2,706 | 7,322,436 | 2 | 4 | 869 | 755,161 | 5,412 | 29,289,744 |
| **Total** | 38,682 | 126,754,052 | 103 | 1,072 | 6,447 | 507,016,208 |

\[ \Sigma X^2 \quad = 126,754,052 \quad 103 \quad 1,072 \quad 6,447 \]

\[ \sum X^2 = 126,754,052 \quad 103 \quad 1,072 \quad 6,447 \]
\[ b. \text{ Realistic productivity value (scores 1-2 and 4-9 scores)} \]

The interval between a score of 0 to 3
\[
\text{interval 0-3} = \frac{(\text{BKA-BKB})}{3} = \frac{(4105 - 2325)}{3} = 593
\]

The interval between the score of 3 to 10
\[
\text{interval 3-10} = \frac{(\text{BKA-BKN})}{7} = \frac{(4105 - 2325)}{7} = 254
\]

c. \text{ Value weight}

Determination of criteria is done by comparing the weight of each criterion. Table 3 compares the priority of each criterion.

**Table 3. Comparison of priority for each criterion**

| Criteria | K1 | K2 | K3 | K4 |
|----------|----|----|----|----|
| K1       | 1  | 3  | 3  | 7  |
| K2       | 1/3| 1  | 1  | 1/5|
| K3       | 1/3| 1  | 1  | 1/3|
| K4       | 1/7| 5  | 3  | 1  |

Then determine the weighting of each criterion, which ranges between 0-1 and the total weight of each column is 1. How to calculate the weight is a number in each cell divided by the sum of all the numbers in one column. Table 4 compares values priority of each criterion.

**Table 4. Comparison value of each criterion**

| Criteria | K1     | K2     | K3     | K4     |
|----------|--------|--------|--------|--------|
| K1       | 0.553  | 0.3000 | 0.375  | 0.820  |
| K2       | 0.184  | 0.1000 | 0.125  | 0.023  |
| K3       | 0.184  | 0.1000 | 0.125  | 0.039  |
| K4       | 0.079  | 0.5000 | 0.375  | 0.117  |

Next step is seeking weights to each criterion. The way to look is by adding up the weights in the column divided by the number of criteria, so that the weight of each criterion are:

\[
\text{Criterion 1} = \frac{(0.553 + 0.300 + 0.375 + 0.820)}{4} = \frac{(2048)}{4} = 0.51 (51\%)
\]

\[
\text{Criterion 2} = \frac{(0.184 + 0.100 + 0.125 + 0.023)}{4} = \frac{(0432)}{4} = 0.11 (11\%)
\]

\[
\text{Criterion 3} = \frac{(0.184 + 0.100 + 0.125 + 0.039)}{4} = \frac{(0448)}{4} = 0.11 (11\%)
\]

\[
\text{Criterion 4} = \frac{(0.079 + 0.500 + 0.375 + 0.117)}{4}
\]
\[
= \frac{(1071)}{4} \\
= 0.27 \ (27\%)
\]

d. **Determining scores and scale**

This stage is the initial stage in determining a score and a scale on the four criteria previously determined weight value to each criterion. **Table 5** is an early stage in finding a score on four criteria.

**Table 5.** Hold preliminary determination of raw material score part shearing

| R1 Jan | R2 Feb | R3 Mar | R4 Apr | R5 May | R6 Jun | R7 Jul | R8 Aug | R9 Sep | R10 Oct | R11 Nov | R12 Dec | Ratio | Period |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|-------|--------|
| 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210  | 3,210   | 3,210   | Perform| Inform |
| 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105  | 4,105   | 4,105   | 10    | Very well |
| 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851  | 3,851   | 3,851   | 9     | Well |
| 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597  | 3,597   | 3,597   | 8     | Enough well |
| 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343  | 3,343   | 3,343   | 7     | Bad |
| 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089  | 3,089   | 3,089   | 6     | |
| 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835  | 2,835   | 2,835   | 5     | |
| 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581  | 2,581   | 2,581   | 4     | |
| 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215   | 3,215   | 3     | |
| 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215   | 3,215   | 2     | |
| 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215  | 3,215   | 3,215   | 1     | |
| 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325  | 2,325   | 2,325   | 0     | |
| 3     | 4     | 3      | 7      | 3      | 7      | 10     | 3      | 6      | 3      | 10      | 5      | Score |
| 0.51  | 0.51  | 0.51   | 0.51   | 0.51   | 0.51   | 0.51   | 0.51   | 0.51   | 0.51   | 0.51    | 0.51    | weight |
| 1.53  | 2.04  | 1.53   | 3.57   | 1.53   | 3.57   | 5.10   | 1.53   | 3.06   | 1.53   | 5.10    | 2.55    | Value |
| 32.64 |       |        |        |        |        |        |        |        |        |         |         | Total |

Interval 3-10=254 and Interval 0-3=593

After conducting initial stage of determining the next score is weighted of the four criteria start with the period December 2018 to December 2019. It was at the start of the period of December 2018 in order to see the total value that will be used to find the value of Productivity Index in the period January to December 2019. And the weighting results can be seen in the following table:

**Table 6.** Results of weighting period July 2019

| RM Shearing | MP Shearing | Shearing | Shearing | Performance |
|-------------|-------------|----------|----------|-------------|
| (sheet)     | (person)    | Time RM | results |             |
| 3,890       | 3           | 1,297    | 7,780   |             |
| 4,105       | 3.58        | 1,368    | 8,208   | 10          |
| 3,851       | 3.41        | 1,283    | 7,700   | 9           |
| 3,597       | 3.24        | 1,198    | 7,192   | 8           |
| 3,343       | 3.07        | 1,113    | 6,684   | 7           |
| 3,089       | 2.9         | 1,028    | 6,176   | 6           |
| 2,835       | 2.73        | 943      | 5,668   | 5           |
| 2,581       | 2.56        | 858      | 5,160   | 4           |
After performing data processing weighting results in each period began with the January to December it will do a recap of the results of the weighting. Table 7 is a recap of the results weighting of each period of one year.

### Table 7. Achieving work

| Period   | Work achievement |
|----------|------------------|
| January  | 3.44             |
| February | 4.33             |
| March    | 3.44             |
| April    | 7.00             |
| May      | 3.88             |
| June     | 7.00             |
| July     | 9.67             |
| August   | 3.88             |
| September| 6.11             |
| October  | 3.88             |
| November | 9.67             |
| December | 4.56             |

e. **Determining productivity**

In the measurement of productivity using Omax model, the weight matrix is divided into ten levels that have a level of value. While the performance indicator consists of the current (sum current value measurement), previous (measuring the number of periods before), and the productivity index \[4\]. Comparison of the measured period with the previous period is to determine whether there is an increase or a decrease in productivity. Table 8 shows objective matrix the period January to December 2019.

### Table 8. Objective matrix in the period April 2019

| RM Shearing (sheet) | MP Shearing (person) | Shearing Time (RM minute) | Shearing results (pcs) | Productivity Criteria |
|--------------------|----------------------|---------------------------|------------------------|-----------------------|
| 3,310              | 3.00                 | 1,297                     | 7,780                  | performance          |
| 4,105              | 3.58                 | 1,368                     | 8,208                  | 10                    |
| 3,851              | 3.41                 | 1,283                     | 7,700                  | 9                     |
| 3,597              | 3.24                 | 1,198                     | 7,192                  | 8                     |
| 3,343              | 3.07                 | 1,113                     | 6,684                  | 7                     |
| 3,089              | 2.90                 | 1,028                     | 6,176                  | 6                     |
| 2,835              | 2.73                 | 943                       | 5,668                  | 5                     |
The analysis is based on the criteria of productivity measurement is performed to determine the criteria that influence and should be improved. The score of each criterion in productivity can be seen in Table 9.

Based on data shown in Table 9, in general it can be said that productivity is good enough, because it is in the range of 3-10. But there is one bad period in criterion 2 with a period in December 2019, It is influenced by external factors, namely by reducing the workforce on the basis of company policy. To solve it is expected an improvement in the other criteria in order to cover the shortage. One is by raising the shearing results in a short time and labor a little, so the cost of output as cheaper. Causal analysis method to be discussed is the cause of productivity decline. Of all the four criteria discussed above the importance of the four factors to determine the cause of the problem. Causal diagram can be seen in Figure 1.

| Performance Indicator | Current | Previous | Index | Index |
|-----------------------|---------|----------|-------|-------|
| Score                 | 7.00    | 3.44     | 1.03  |       |

### Table 9. Score criteria productivity

| Period     | RM Shearing (sheet) | MP Shearing (person) | Shearing Time RM (minute) | Shearing results (pcs) |
|------------|---------------------|-----------------------|---------------------------|-------------------------|
| January    | 3                   | 7                     | 3                         | 3                       |
| February   | 4                   | 7                     | 4                         | 4                       |
| March      | 3                   | 7                     | 3                         | 3                       |
| April      | 7                   | 7                     | 7                         | 7                       |
| May        | 3                   | 7                     | 7                         | 3                       |
| June       | 7                   | 7                     | 7                         | 7                       |
| July       | 10                  | 7                     | 10                        | 10                      |
| August     | 3                   | 7                     | 7                         | 3                       |
| September  | 6                   | 7                     | 6                         | 6                       |
| October    | 3                   | 7                     | 7                         | 3                       |
| November   | 10                  | 7                     | 10                        | 10                      |
| December   | 5                   | 1                     | 5                         | 5                       |
| Amount     | 64                  | 78                    | 76                        | 64                      |
5. Conclusion

Based on the results of data processing and analysis above that the increase in productivity index in the period from February, April, June, September, and November 2019. While the decline in productivity index occurred in January, March, May, July, August, October, and December 2019. The increase in productivity the highest in the period of November 2019, that the performance indicator value of 1.49 and the lowest productivity decline in the period of August 2019, with a value of 0.60 performance indicator.

From the results of the analysis score productivity criteria, the criteria that still needs to be improved to achieve better productivity is the criteria one, three and four, the raw material criteria shearing, shearing time, and the result of shearing. Then it can be concluded that:

- Productivity in the shearing process raw materials in PT. Fuji Technica Indonesia in the period January to December 2019 fluctuated productivity.
- Doing drafts Improvement by performing the shearing machine is to be made tools laying shearing result of raw material as well as a stopper on the pallet to trim raw material shearing results.

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