Productivity measurement using Objective Matrix: case study in plate mill

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Abstract. A decline of production level in December 2018 requires an evaluation. Productivity measurement is required to calculate performance. The purpose of this study is to measure the level of productivity using the objective matrix (omax). There were four steps to perform Omax. First step is select performance criteria, second is establish performance scales, third is rate the relative importance of the performance criteria, and the last is calculate the team productivity indicator. There were five ratios that become performance criteria, namely actual production compared to the target, material consumption, available time, makeup water consumption, and electricity consumption. The weight of each ratio is known in sequence from ratio 1 to ratio 5 were: 30%, 20%, 30%, 5%, and 15%. The performance index obtained the 3rd week has the highest productivity value, while the 4th week has the lowest productivity value, but the value is higher than standard value. From the value per ratio, we learned the ratio 1 has a fairly good performance, while the ratio 3 performance is considered less, because it is in the red zone.

1. Introduction
There was a decline in production levels in production line at XYZ, a company that manufactures plates, within a few weeks. Manager wanted to know the level of productivity to evaluate the resources they have. Resources as the input for production are generally materials, labour, and machines [1].

One of the most critical aspects of productivity measurement is the capability to acknowledge which factors are committed to changes in productivity [2]. Relationships such as enhancement, decline, or no changes in productivity can be caused by any figure of changes in input and output levels [2]. Partial productivity measures can uplift management at the source of productivity alteration [2].

In general, productivity is the ratio between output and input. Based on [3] the aim of productivity measurement is technology, efficiency, real cost savings, benchmarking production processes, and living standards. It is important to measure the productivity level to achieve those purpose. Depend on [4] there are four approach to do productivity measurement, that are: self-audit, extended audit, self-assessment, and benchmarking. Self-audit is based on questionnaire, extended audit is performed by expert, self-assessment focus on measuring of trends, and benchmarking is the process of comparing and measuring with another organisation [4].

This paper determination is to show the calculation of productivity level applying self-assessment approach. The intention is to practice continuous improvement. Objective matrix (Omax) is a tool to measure productivity which is widely used by some previous researchers. It helped to develop a
composite index for the entire system or to individuals the entire system [5]. This evaluation model has an aspect which is the performance criteria of the work group integrated into the matrix [6].

Wahyuni [7] implementing Omax to measure the level of productivity in the injection area of a shoe factory. Faridz [8] calculated the optimal production of sugar using Omax. Sirajuddin [9] applying Omax to measure productivity in steel mills. In addition to being used in manufacturing, the Omax method can also be applied to the service sector. For example, done by [10] who measure productivity in emergency services in Turkey. Yosan [11] also used Omax to measure productivity in building maintenance services. Likewise [12] is using Omax to perform productivity in education. Omax also can be used to measure company performance, integrating with balance scorecard or human scorecard [13][14].

The purpose of this study is to measure the level of productivity using the Omax method. Productivity will be translated into several criteria [5]. This article is expected to contribute to production managers in evaluating productivity levels. In addition, this article is expected to contribute as an enrichment for researchers and students.

2. Method
Depend on [15], there are four steps to perform Omax. First step is select performance criteria, second is establish performance scales, third is rate the relative importance of the performance criteria, and the last is calculate the team productivity indicator [15]. The selected productivity criterion is a calculation of productivity which then the level is determined to measure the productivity of the company [16]. The performance scales are attached at three levels [15]:
- Level 0: the lowest level of performance over a recent period under normal operating conditions.
- Level 3: the current baseline level of performance.
- Level 10: a stretch goal (a realistic estimate of the results) that the team can achieve with its expected capital allocation over the course of the project.

The project-management team determine weighting factors to each category to manifest their perceptions of its importance [15]. The amount of the weighting factors should equivalent one hundred percent [15]. The calculation of productivity indicators consists of three, namely [17]:
- Current, which is the result of measuring the productivity of the current period obtained from the sum of the values of each criterion
- Previous, i.e. the results of previous productivity measurement
- Index, which is an indication of changes in productivity that occur in the company. Value index productivity (IP) is obtained by the formula: IP = ((Current-Previous) / Previous) x 100%

3. Result and discussion
3.1. Performance criteria
Following are the results of data collection on consumption of raw materials and supporting materials at XYZ's production division. The following data are indicator data that influence productivity in the production division. The data collected was data in December 2018. This is a weakness of this article, the author did not get any other data besides the data for December 2018 due to limited research time.

| Week | Production Target (metric ton) | Production Actual (metric ton) | Material Usage (kilogram) | Plan Availability (%/metric ton) | Air Make Up (x 10 m³/metric ton) | Electricity (kilowatt) |
|------|-------------------------------|-------------------------------|---------------------------|---------------------------------|---------------------------------|-----------------------|
| A    | B                             | C                             | D                         | E                               | F                               |                       |
| 1    | 3662.11                       | 3614.11                       | 18000                     | 721.29                          | 11909                           | 519667                |
| 2    | 3417.97                       | 3348.54                       | 18000                     | 664.86                          | 12806                           | 513331                |
| 3    | 2441.41                       | 2358.59                       | 11000                     | 621.03                          | 8964                            | 391935                |
| 4    | 4394.53                       | 4357.74                       | 18000                     | 871.32                          | 13692                           | 607022                |
Table 2 presents the ratios that become criteria in measuring productivity. Ratio 1 is the ratio used as a determination of the productivity of the actual output of production against the production target which is made every week. This ratio compares actual production with production targets. Ratio 2 is the ratio used as a determination of the productivity of material consumption to the actual plate production made every week. This ratio compares material consumption with actual production. Ratio 3 is the ratio used as a determination of the productivity of the available time to the actual production of plates that are made every week. This ratio compares the time available with the actual production. Ratio 4 is the ratio used to determine the productivity of air make up consumption against the actual production of plates that are made every week. This ratio compares the consumption of air make up with actual production. Ratio 5 is the ratio used as a determination of the productivity of electrical energy consumption against the actual production of plates that are made every week. This ratio compares electrical energy consumption with actual production.

| Ratio 1  | Ratio 2  | Ratio 3  | Ratio 4  | Ratio 5  |
|----------|----------|----------|----------|----------|
| (B/A)    | (C/B)    | (D/B)    | (E/B)    | (F/B)    |
| 0.9869   | 49.805   | 0.1996   | 32.951   | 143.7886 |
| 0.9797   | 53.755   | 0.1986   | 38.244   | 153.2998 |
| 09661    | 46.638   | 0.2633   | 38.005   | 166.1734 |
| 0.9916   | 41.306   | 0.1999   | 31.420   | 139.2974 |

3.2. Performance scale
After the ratio has been determined, the next step is determining the target matrix. In determining the target matrix there are three levels as a reference. Determination of the target matrix of the worst productivity value is expressed at level 0. The performance value obtained from the average value of each performance ratio that occurs during the observation is stated at level 3. Whereas for the determination of the target matrix the company expects in the future is stated at level 10. Table 3 below is a performance scale for minimum, standard, and maximum values. The minimum scale is obtained from the smallest ratio value, the standard value is the average value of the ratio, while the maximum value is the largest ratio value.

Minimum, standard, and maximum values that have been determined, then become the standard interval for each level of performance. In Omax there are 10 performance levels. The minimum value means level 0, the default value means level 3, and the maximum value means level 10. Here is a formula for creating intervals:

\[
\text{interval level } 1 \text{ and level } 2 = \frac{\text{Level 3} - \text{level 0}}{3-0}
\]

\[
\text{interval level } 4 \text{ to level } 9 = \frac{\text{Level 10} - \text{level 3}}{10-3}
\]

For example, in ratio 1:
- To determine interval level 1 and level 2:
  \[\frac{0.9811 - 0.9661}{3} = 0.005\]
- To determine interval level 4 to level 9:
  \[\frac{0.9916 - 0.9811}{7} = 0.0015\]

So, for level 1: 0.9661 + 0.005 = 0.9711 and for level 2: 0.9711 + 0.005 = 0.9761. And for level 4: 0.9811 + 0.0015 = 0.9826, for level 5: 0.9826 + 0.0015 = 0.9841, and so on.
Table 3. Performance scale

| Performance scale               | Ratio 1 | Ratio 2 | Ratio 3 | Ratio 4 | Ratio 5 |
|---------------------------------|---------|---------|---------|---------|---------|
| Minimal (Level 0)               | 0.9661  | 4.1306  | 0.1986  | 3.1420  | 139.2974|
| Standard (Level 3)              | 0.9811  | 4.7876  | 0.2153  | 3.5155  | 150.6398|
| Maximal (Level 10)              | 0.9916  | 5.3755  | 0.2633  | 3.8244  | 166.1734|

3.3. Performance rate

Weighting is the weight of each productivity criterion to total productivity. Each of the predefined criteria has a different effect on the level of the unit being measured. For this reason, it is necessary to include a weight which states the degree of importance (in percentage) which shows the relative influence of these criteria on the productivity of the work unit measured. Weighting is done subjectively by the production manager. Table below is the performance rate.

Table 4. Performance rate

| Criteria                         | Weight (%) |
|----------------------------------|------------|
| Actual achievement production    | 30         |
| (Ratio 1)                        |            |
| Material consumption (Ratio 2)   | 20         |
| Time availability (Ratio 3)      | 30         |
| Air make up consumption (Ratio 4)| 5          |
| Electricity consumption (Ratio 5)| 15         |

3.4. Productivity index

The measurement results will be used as an evaluation material for daily operational processes, so that company activities can be more efficient and effective. To find out how much the level of change in the performance of current productivity indicators against the standard value of productivity (first) and against the indicators of previous achievement. If the value of the change shows a positive value, then it can be said that there is a change that has a positive impact (increase), and vice versa if the value of the change shows a negative value, then it can be said that there is a change that has a negative impact (decrease).

Figure 1 is an objective matrix for measuring productivity in the first week. Seen in the picture, the values at each level (level 0 to level 10). The blue bar is the value in the ratio of 1 to 5 in the first week. For example, in the ratio 1, the value is 0.9869, the value approaches level 7, then, the score for the ratio 1 in the first week is 7. To calculate the performance value is a score of 7 times the ratio 1 weight of 30, obtained 210. The sum of the performance values the ratio of 1 to 5 for the first week is 300. Thus, the performance index is obtained at 18%.
Figure 1. Objective matrix week 1

Table 5 below shows the performance ratio 1 to ratio 5 based on Omax. The red color indicates below-standard performance (level 0 to level 2). Yellow is the standard performance ratio, meaning

| Ratio 1 | Ratio 2 | Ratio 3 | Ratio 4 | Ratio 5 |
|--------|--------|--------|--------|--------|
| 0.9869 | 49.805 | 0.1966 | 32.951 | 143.7886 |
| 0.9916 | 53.755 | 0.2633 | 38.244 | 166.1734 |
| 0.9901 | 52.915 | 0.2565 | 37.803 | 163.9543 |
| 0.9886 | 52.075 | 0.2496 | 37.362 | 161.7352 |
| 0.9871 | 51.235 | 0.2428 | 36.921 | 159.5161 |
| 0.9856 | 50.395 | 0.2359 | 36.479 | 157.2971 |
| 0.9841 | 49.556 | 0.2290 | 36.038 | 155.0780 |
| 0.9826 | 48.716 | 0.2222 | 35.597 | 152.8599 |
| 0.9811 | 47.876 | 0.2153 | 35.155 | 150.6398 |
| 0.9761 | 45.686 | 0.2097 | 33.910 | 146.8590 |
| 0.9711 | 43.496 | 0.2042 | 32.665 | 143.0782 |
| 0.9661 | 41.306 | 0.1986 | 31.420 | 139.2974 |

| Performance Indicator | Current | Previous | Index |
|-----------------------|---------|----------|-------|
| Score                 | 355     | 300      | 18%   |
| Weight                | 5       | 15       |       |
| Value                 | 10      | 15       |       |

Figure 2. Overall productivity

If we pay attention to the achievement value of performance per week (figure 2), the achievement of production per week is above the standard productivity value of 300. As for the third week, the performance index value of 540 is the highest performance value in December 2018 with the index reaching 35%. This is influenced by the low material consumption, low air makeup consumption and using low electrical energy with the lowest plan availability for 4 weeks which shows that during the production process is going according to planning. And the lowest performance value was in the fourth week i.e. 330 with a performance index of -39%. In the fourth week experiencing some production problems.

Table 5 below shows the performance ratio 1 to ratio 5 based on Omax. The red color indicates below-standard performance (level 0 to level 2). Yellow is the standard performance ratio, meaning...
that the performance approaches the target to be achieved (level 3 to level 6). Green indicates the performance has reached the target (level 7 to level 10). In the third week there are 2 ratios in the red category which are the ratio 1 and ratio 2. This is because the supply of material runs out so that it affects the actual production. However, overall, this illustrates the value of performance in the third week is the best performance value. If we pay attention to performance per ratio, ratio 1 has a fairly good performance, while the ratio 3 performance is considered less, because it is in the red zone.

| Week | Ratio 1 | Ratio 2 | Ratio 3 | Ratio 4 | Ratio 5 |
|------|--------|--------|--------|--------|--------|
| 1    | 0.9869 | 49.805 | 0.1996 | 32.951 | 143.7886 |
| 2    | 0.9797 | 53.755 | 0.1986 | 38.244 | 153.2998 |
| 3    | 0.9661 | 46.638 | 0.2633 | 38.005 | 166.1734 |
| 4    | 0.9916 | 41.306 | 0.1999 | 31.420 | 139.2974 |

4. Conclusion
Based on the calculation results and the description above, it can be concluded that the productivity of XYZ in December 2018 when viewed from the performance in a month, the 3rd week has the highest productivity value, while the 4th week has the lowest productivity value, but the value is higher than standard value. If seen from the value per ratio, the ratio 1 has a fairly good performance, while the ratio 3 performance is considered less, because it is in the red zone.

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