AFSSAAE

Advances in Food Science, Sustainable Agriculture and Agroindustrial Engineering 2023, 6(4), 350-361
ISSN 2622-5921

ORIGINAL RESEARCH Open Access

Robusta coffee processing productivity analysis using objective matrix (OMAX) method (Case study at PT Tinkerbels Permata Indah, Bogor, West Java)

Panji Deoranto*, Abiyyu Yazid Hilal and Isti Purwaningsih

Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia

KEYWORDS

Coffee processing
Objective matrix
Pairwise comparison
Productivity analysis
Robusta coffee

ABSTRACT

PT Tinkerbels Permata Indah is one of the companies engaged in the coffee processing industry. The high market demand for coffee products made from robusta coffee requires PT Tinkerbels Permata Indah to continuously produce more coffee effectively and efficiently. Therefore, companies need to measure productivity to determine the performance of using several inputs to produce output. This research aimed to analyze the productivity level of robusta coffee bean production and to make a proposed improvement plan for PT Tinkerbels Permata Indah. The method used to measure productivity was the objective matrix (OMAX) method. The weight of each criterion was obtained with the help of the pairwise comparison method by filling out a questionnaire by the three experts involved. The results show that the company's highest productivity achievement was 5.893 in April 2022, and the lowest was in September 2022, with a current value of 0.880. Proposed improvements include companies needing to pay attention to their warehouses by maintaining temperature and humidity so that materials are not damaged by warehouse pests, implementing flexible daily hours to reduce wastage of employee work time, implementing an energy-saving culture, conducting energy audits, and implementing machinery maintenance management.

Introduction

The agricultural sector has a critical position in national economic development because this sector is the foundation of most Indonesians to find jobs. One of the leading commodities owned by Indonesia from the agricultural sector of the plantation sub-sector is coffee. According to data from the Central Statistics Agency, in 2022, Indonesia's coffee production reached 774,96 thousand tons with total coffee exports of 433.35 thousand tons. The high coffee production and area of coffee plantations make Indonesia occupy the fourth position as the largest coffee-producing and exporting country in the world, after Brazil, Vietnam, and Colombia (Winingsih and Septiani, 2020).

PT Tinkerbels Permata Indah is a company engaged in food and beverage headquartered in South Jakarta. One of its business units is the coffee processing industry, which is located in Sentul Village, Babakan Madang District, Bogor Regency, West Java. PT Tinkerbels Permata Indah uses several coffee beans as raw materials, such as robusta, arabica, and gayo, with a production capacity of approximately 6 tons per month. The type of coffee most widely used by PT Tinkerbels Permata Indah because of the high market demand is robusta coffee. Robusta coffee has several characteristics that make it the coffee with the highest demand. The characteristics of robusta coffee include having a taste like chocolate, slightly sour, more bitter, and has a distinctive and sweet aroma.

The high market demand for robusta coffee products requires PT Tinkerbels Permata Indah to effectively and efficiently produce more coffee continuously. PT Tinkerbels Permata Indah always prioritizes the quality and productivity of its products. However, the level of coffee processing productivity in this company still tends to fluctuate, so there is still much waste on the resources used. The company's production system that produces many products on demand makes it difficult for

*Corresponding author
E-mail address: deoranto@ub.ac.id

Received on 29 November 2023, Revised on 14 December 2023, Accepted on 20 December 2023

companies to utilize their resources such as the number of idle hours of employees and machines, inefficient use of electrical energy and the quality of different raw materials due to the absence of sufficient inventory. Therefore, PT Tinkerbels Permata Indah needs to measure productivity to determine the performance of using several inputs to produce output.

The method used in this study is the Objective Matrix (OMAX) method. Productivity measurement using OMAX combines several productivity criteria that have been given weight by the company based on the level of importance to the company into an integrated form and related to each other (matrix) (Nurwantara et al., 2021). The advantages of the OMAX method include being able to identify various criteria that are considered to have a high level of importance in increasing productivity (Sayuti et al., 2021). By using the OMAX method, the company is involved in determining weighting according to the level of importance of each criterion in order to obtain more objective and flexible results (Luhulima, et al., 2017). The weighting method that can be used in measuring the productivity of the OMAX method is pairwise comparison. The pairwise comparison method can be used to provide weights relative to compound criteria (Priangga and Suryani, 2019). Comparison of criteria levels in the pairwise comparison method used a scale of 1 to 9 (Abastante et al., 2018).

Based on the aforementioned issues, this research has several objectives. The first objective was to analyze the productivity level of robusta coffee bean production at PT Tinkerbels Permata Indah with the OMAX method. The second objective was to design a proposed improvement plan given to PT Tinkerbels Permata Indah for robusta coffee bean production for improving the company's productivity level.

Research and Methods

Problem limitation

Limitations of the problem in this study include productivity measurement at PT Tinkerbels Permata Indah, which was carried out using the company's historical data from October 2021 to December 2022 with a monthly period. The productivity measurement criteria used include the productivity of employee working hours, the productivity of using raw materials, the productivity of using machine working hours, and the productivity of using electrical energy. The output used in this study is the amount of coffee beans obtained in kilograms (kg).

Preparation of questionnaires

The questionnaire was prepared to determine the degree of importance of each prospective respondent involved. Three respondents (i.e., one production manager and two production employees) were chosen based on recommendations from the human resource development manager. Apart from that, the three respondents were employees with more than five years of work experience. Thus, the respondents were considered to have understood the most important problems encountered in the company's production process. The questionnaire results were then processed using the pairwise comparison method to obtain the weight of each criterion. The validity testing carried out in this study utilizes the face validity method. Face validity is the most basic validity testing method that uses a qualitative approach to be discussed to create a quality questionnaire.

Data collection

Data collection carried out in this study consists of several methods, including interviews, documentation, observation, and questionnaires. The data needed as input in this research process is divided into two types of data, including primary data, which includes the results of filling out questionnaires related to determining the degree of importance of each productivity criterion. Secondary data consists of raw materials, employee working hours, electrical energy, machine working hours, and final products in the form of Sangria coffee beans.

Calculation of criteria weights using the pairwise comparison method

a. Preparation of pairwise comparison matrix

The preparation of matrix was carried out by comparing the elements used in pairs according to the criteria. The prepared matrix was given to respondents as a questionnaire that needed to be filled out to obtain the weight of each criterion. The pairwise comparison matrix table can be seen in Table 1. Filling out the pairwise comparison matrix questionnaire was done by giving numbers, thus the relative importance of one element to other elements is known. The number used was a paired comparison rating scale that can be seen in Table 2.

Table 1. Pairwise comparison matrix (Munthafa and Mubarok, 2017)

	Criteria-1	**Criteria-2**	**Criteria-3**	**Criteria-n**
Criteria-1	C11	C12	C13	C1n
Criteria-2	C21	C22	C23	C2n
Criteria-3	C31	C32	C33	C3n
Criteria-n	Cn1	Cn2	Cn3	Cmn

Notes: Criteria-n represented the criteria used; and K_{ij} represented the ratio of weights between comparison values

Table 2. Pairwise comparison rating scale (Munthafa and Mubarok, 2017)

Intensity of Interest	**Description**
1	Both criteria have equal importance
3	One criterion has a slightly more important value than the other
5	One criterion has more importance than the other
7	One criterion has a very important value over the other
9	One criterion has an absolute value of importance over another
2, 4, 6, 8	Values between two adjacent tolerance values

Table 3. Index ratio value (Odu, 2019)

N	1	2	3	4	5	6	7	8
IR	0	0	0.58	0.90	1.12	1.24	1.32	1.41

b. Calculating priority vectors

The calculation of priority vectors was carried out in several stages as follows:

1. Sums the values obtained by each criterion in each matrix column , following the equation below:
   $\text{Criteria} - 1 = C11 + C12 + C13 + C1n$ ....(1)
2. Divide the each column's values by the total of the corresponding columns to obtain matrix normalization, by using the equation below:
   $\frac{C11}{C11+C12+C13+C1n}$ .....(2)
3. Summing the values of each row and then dividing by the number of elements to obtain an average value, using the equation as follows:
   $EV = \frac{\text{Number of Rows n}}{\text{Number of Elements (n)}}$.....(3)

c. Consistency measuring

Consistency measurement was carried out by measuring the value of Consistency Index (CI) and Consistency Ratio (CR). Weighting can be said to be qualified if the CR value ≤ 0.1 (Faisal and Permana, 2015). Before measuring the CI value, it is necessary to know the Maximum Eigen value first. The formula used to calculate the value of the maximum eigen value was:

λmax = (Number of columns 1 x EV1) + (Number of columns 2 X EV2) + (Number of columns 3 x EV3) + (Number of columns n x EVn).....(4)

The formula used to calculate the CI was as follows:

$CI = \frac{\lambda max - n}{n-1}$..... (5)

The calculation of CI was done by the formula below:

$CR = \frac{CI}{IR}$ ..... (6)

Where,
CI is the consistency index
λmax is the maximum Eigen value
n isthe number of elements
CR is the consistency ratio
IR is the index ratio

The IR value was then checked for hierarchical consistency. If the IR value obtained exceeds 10%, then the assessment made by respondents needs to be improved. However, if the CI/CR division result produces a value less than or equal to 0.1, then the calculation result can be declared correct. The IR value was adjusted to the number of criteria used, as shown in Table 3.

Data analysis using objective matrix (OMAX) method

a. Compiling the OMAX matrix

The preparation of the OMAX matrix was the first step in data analysis using the OMAX method. The preparation of the matrix consists of three stages, which include:

1. Defining, is a definition of criteria used as a reference for company productivity.
2. Quantifiying, is an assessment stage regarding the productivity achievement of each calculated criterion.

3. Monitoring, is an assessment of the achievement level of company productivity in the measured period.

b. Calculating performance criteria

The performance ratio of each criterion was calculated by dividing the actual production amount by the input in the form of criteria to be calculated in a predetermined period. The measurement formulation for each criterion includes the equations below:

Performance I

$$= \frac{\text{Actual product quantity (kg)}}{\text{Amount of raw materials (kg)}} \quad \text{.....(7)}$$

PerformanceII

$$= \frac{\text{Actual product quantity (kg)}}{\text{Number of hours worked by employees } (hours)} \quad \text{.....(8)}$$

Performance III

$$= \frac{\text{Actual product quantity (kg)}}{\text{Amount of electrical energy (Kwh)}} \quad \text{.....(9)}$$

Performance IV

$$= \frac{\text{Actual product quantity (kg)}}{\text{Number of working hours of the machine (hours)}} \quad (10)$$

c. Determining the average value (level 3)

The calculation of the average value of performance achieved was done by averaging the ratio value of each criterion. The formula used to calculate the average value achieved during (level 3) was as follows:

$$\mu = \frac{1}{n}\sum_{i=1}^{n} xi \quad \text{.....(11)}$$

Where,
M is the average ratio of each measured criterion
N is the amount of data
I is theratio of the i-th criterion

d. Determine the smallest value (level 0)

The smallest value is obtained from the Lower Control Limit (LCL) value of each criterion. The following formula was carried out to calculate the LCL value:

$$LCL = \mu - k\,\sigma \quad \text{.....(12)}$$

Where,
LCL is the lower control limit
M is the average ratio of each measured criterion
k is the constant
σ is the standard deviation

e. Setting productivity targets (level 10)

The productivity target to be achieved is the productivity target expected by the company in a certain period. This priority productivity target was placed at level 10 and obtained from the Upper Control Limit (UPL). The upper control limit was calculated using the following formula:

$$UPL = \mu + k\,\sigma \quad \text{..... (13)}$$

$$\sigma = \sqrt{\frac{\sum(xi-\mu)^2}{n}} \quad \text{..... (14)}$$

Where,
UPL is the limits of control over
M is the average ratio of each measured criterion
σ is the standard deviation
n is the amount of data
xi is theperformance

f. Determining realistic productivity values (level 1-2 and level 4-9)

This value is an estimate of the lowest to highest value so that it is known to achieve the company's productivity level in a certain period. Level 1-2 is obtained from the results of interpolation between level 0 values and level 3 values. The equation used to find the values of levels 1-2 was as follows:

Interval 1-2

$$= \frac{\text{Average (Level 3)} - \text{Lowest level (level 0)}}{3-0} \quad \text{..... (15)}$$

Then, to obtain levels 4-9, it is necessary to interpolate between the values of level 3 and level 10, using the following formula:

Interval 4-9

$$= \frac{\text{Productivity expectations (Level 10)} - \text{Average(level 3)}}{10-3} \quad \text{.....(16)}$$

g. Calculating score, weight, and value

Score is a level that indicates the existence of the level of productivity of the measurement results. Weight is the magnitude of the importance of each productivity criterion to total productivity. The weight value was determined based on data processing using the pairwise comparison method. Value is the result of the multiplication between the score and the weight on each measured criterion.

h. Measuring performance indicators

This stage is the summation of all values obtained by each criterion in the OMAX table. The results show the performance level of all criteria in the production of robusta coffee beans every month.

The measurement of performance indicators was divided into three parts as follows:

1. Current, is the number of values obtained by each criterion when the measurement is made
2. Previous, is the sum of values obtained from measurements made in the previous period
3. Productivity Index, is an indicative value that shows the company productivity changes.

The formula used to obtain the productivity index value was as follows:

$$\text{Productivity Index} = \frac{\text{Current}-\text{Previous}}{\text{Previous}} \text{ x } 100\% \quad (17)$$

Determination of proposed productivity improvements

Proposals for improving company productivity are prepared based on the results obtained from the productivity analysis and evaluation stages that have been carried out. The results obtained from the analysis and evaluation stage reflect the actual condition of the company, which can be used as a basis for the preparation of improvement proposals. The proposed productivity improvement is expected to bring the company to its highest level of productivity. The formula used to design and proposed for productivity improvements was as follows:

$$\text{Productivity Criteria} = \frac{\text{Number of products of the last period}}{\text{Score score 10 criteria}} \quad \ldots\ldots\ldots\ldots\ldots (18)$$

Results and Discussion

Input and output data PT Tinkerbels Permata Indah

The input and output data used to measure productivity at PT Tinkerbels Permata Indah were 15 months of production datafrom October 2021 to December 2022. The input data in this study includes several resources used in the production process, including the amount of raw material usage, electricity usage, employee hours, and machine hours. The output data in this study is the amount of product obtained from the production of roasted coffee beans. The input and output data of PT Tinkerbels Permata Indah are presented in Table 4.

Table 4 shows a fluctuating trend in using of the four inputs and output gains at PT Tinkerbels Permata Indah. The highest usage for all four inputs and outputs was obtained in July 2022, possibly due to a high market or consumer demand for robusta-based coffee products. In addition, instability in input usage has also influenced the products produced or the composition of robusta coffee. The production system based on orders received by the company also affects the employee's total working time, machine working hours, and the use of electrical energy.

Weighting of productivity criteria

The measurement criteria used have different influences on the company's productivity level. The determination of weights in this study was carried out with the help of paired comparison methods to compare one criterion with other criteria carried out by three experts. The weights generated based on data processing using the pairwise comparison method are presented in Table 5.

The criteria for the use of raw materials have the highest weight according to experts, as presented in Table 5. The three experts involved have a similar perspective through questionnaires used to assess the importance of the criterion that the use of raw materials is the most influential criterion on production productivity. This was in line with the statements of Satar and Israndi (2019) that raw materials are a vital factor for companies to increase productivity due to their influence on the product's quality and the operational costs. Furthermore, the use of electrical energy is the criterion with the lowest weight compared to other criteria. According to the three experts, the total electricity usage is still relatively normal every month and is not too burdensome for operational costs despite its instability.

Performance calculation of productivity criteria

The calculation of performance value was carried out to determine the ratio of resource use to the product produced, in other words performance is a quantity that reflects the extent to which the company's ability to utilize resources in carrying out its production activities. The results of the calculation of performance productivity criteria are presented in Table 6.

Table 6 shows that the performance value of each criterion constantly changes every period. These changes indicate that the company's productivity remains unstable. This is caused by several factors, including differences in the quality of the raw materials used because the company lacks raw material storage facilities. Secondly, unstable daily demand affected the daily roasting frequency and performance as the amount of coffee produced was lower than the machine capacity. Finally, many idled employees working time and inefficient electrical energy usage due to erratic production quantities may also lower the company's performance . According to Deorento et al. (2016), the lack of maximum worktime utilization of is the underlying low productivity.

Table 4. Input and output data of PT Tinkerbels Permata Indah

Period	Output (kg)	Raw Materials (kg)	Employee Working Hours (hours)	Use of Electrical Energy (kWh)	Machine Working Hours (hours)
October 21	1680	2062	264	272.68	74.93
November 21	2574	3192	360	405.25	115.55
December 21	3442	4272	360	571.50	154.61
January 22	810	984	216	133.65	35.85
February 22	1198	1464	288	169.94	53.24
March 22	1786	2172	336	259.32	79.11
April 22	857	1032	240	131.59	37.70
Mey 22	639	792	192	105.66	28.68
June 22	1193	1476	288	171.28	53.47
July 22	5436	6660	528	752.04	242.00
August 22	2067	2520	312	311.20	91.71
September 22	656	816	192	107.67	29.62
October 22	599	744	192	95.60	26.92
November 22	685	852	192	112.97	30.81
December 22	2175	2664	288	312.68	96.81

Table 5. Weight of PT Tinkerbels Permata Indah Productivity Criteria

No	Productivity Criteria	Weight	Percentage (%)
1	Use of Raw Materials	0.554	55.4
2	Employee Working Hours	0.120	12.0
3	Machine Working Hours	0.229	22.9
4	Use of Electrical Energy	0.097	9.7
	Total	1	100

Table 6. Performance productivity criteria of PT Tinkerbels Permata Indah

Period	Raw Materials (kg/kg)	Employee Working Hours (kg/hours)	Use of Electrical Energy (kg/kWh)	Machine Working Hours (kg/hours)
October 21	0.815	6.364	6.161	22.420
November 21	0.806	7.150	6.352	22.276
December 21	0.806	9.561	6.023	22.263
January 22	0.823	3.750	6.061	22.594
February 22	0.818	4.160	7.050	22.502
March 22	0.822	5.315	6.887	22.577
April 22	0.830	3.571	6.513	22.730
Mey 22	0.807	3.328	6.048	22.284
June 22	0.808	4.142	6.965	22.312
July 22	0.816	10.295	7.228	22.463
August 22	0.820	6.625	6.642	22.539
September 22	0.804	3.417	6.093	22.229
October 22	0.805	3.120	6.266	22.252
November 22	0.804	3.568	6.064	22.230
December 22	0.816	7.552	6.956	22.467
Average	0.813	3.352	6.487	22.409

Calculation of average value (level 3), lowest value (level 0), target value (level 10), actual value (level 1-2 and level 4-9)

The calculation of the average value is the first stage carried out to complete the OMAX productivity matrix. The acquisition of a level 3 score from each criterion was calculated by the formula (11). If the average value is known, the lowest and highest productivity performance values that the company may achieve within the measurement time range are determined. The lowest value was used as the level 0 value in the OMAX matrix table. The lowest possible gain recorded by the company was calculated based on the lower control limit value as

contained in formula (12). While, the target value (level 10) was obtained using the upper control limit formula listed in formula (13). The next step in filling in the OMAX matrix table was to calculate the actual value at the unfilled levels, where the value was divided into two based on the calculation, namely levels 1-3 and 4-9. These values were obtained by calculation according to the formula (15) and formula (16), as shown in Table 7.

Score, weight, and value determination

The company's score every month during the measurement period was determined based on the amount of performance obtained by each criterion in that month. This determination is made by looking at level value that is just below the performance value obtained by each criterion. Lesmana et al. (2020) stated that the purpose of setting the score is to determine theeach criterion's performance when the measurement takes place at which level.

The weight indicator is the amount of weight imposed on each criterion based on the influence given by the criterion on the achievement of total productivity. The acquisition of these values was then entered into the weight column of each criterion on the matrix. The examples of setting score values and weights on the matrix are presented in Table 8.

The amount of value on OMAX can be determined by multiplying the score obtained by each criterion used when measuring with the amount of weight charged against each criterion to the total productivity level. According to Irwansyah et al. (2022), the value obtained by each criterion may then be calculated to fill in the performance indicator column to obtain the monthly productivity level as long as the measurement range has decreased or increased.

Table 7. Calculation results of level 0-10 values

Level	Use of Raw Materials	Employee Working Hours	Use of Electrical Energy	Machine Working Hours
10	0.839	7.811	7.349	22.903
9	0.835	7.476	7.226	22.832
8	0.831	7.140	7.103	22.760
7	0.828	6.804	6.979	22.689
6	0.824	6.468	6.856	22.618
5	0.821	6.133	6.733	22.546
4	0.817	5.797	6.610	22.475
3	0.813	5.461	6.487	22.404
2	0.805	4.678	6.200	22.237
1	0.797	3.894	5.913	22.071
0	0.788	3.111	5.626	21.905

Table 8. Determination of score and weight for October 2021

Use of Raw Materials	Employee Working Hours	Use of Electrical Energy	Machine Working Hours	Productivity Criteria
0.815	6.364	6.161	22.420	Performance
0.839	7.811	7.349	22.884	10
0.835	7.476	7.226	22.816	9
0.831	7.140	7.103	22.749	8
0.828	6.804	6.979	22.681	7
0.824	6.468	6.856	22.613	6
0.821	6.133	6.733	22.545	5
0.817	5.797	6.610	22.477	4
0.813	5.461	6.487	22.409	3
0.805	4.678	6.200	22.251	2
0.797	3.894	5.913	22.093	1
0.788	3.111	5.626	21.934	0
3	5	1	3	*Score*
0.554	0.120	0.097	0.229	*Weight*
1.66238	0.358757	0.09736363	0.6867766	*Value*

Table 9. Productivity criteria score October 2021 – December 2022

Period	Raw Material	Employee Working Hours	Use of Electrical Energy	Machine Working Hours
October 21	3	5	1	3
November 21	2	8	2	2
December 21	2	10	1	2
January 22	5	0	1	5
February 22	4	1	7	4
March 22	5	2	6	5
April 22	7	1	3	7
Mey 22	2	0	1	2
June 22	2	1	6	2
July 22	3	10	9	3
August 22	4	6	4	4
September 22	1	0	1	1
October 22	1	0	2	2
November 22	1	0	1	2
December 22	3	9	6	3

Partial productivity analysis

Partial productivity analysis was intended to determine how much productivity level is obtained by each criterion, where these criteria are factors that affect the amount of company productivity. The size of the influence given is based on the acquisition of scores obtained by each criterion in the measurement time range, as shown in Table 9.

1. Raw material

The factor causing the production process's efficiency is inseparable from the high quality of coffee beans used as raw materials due to the low rate of depreciation during the roasting process. This aligns with Sentosa and Trianti's (2017) statement that raw materials with high quality and no defects can produce good-quality products.

The main factor that caused the low score in that month was the deficient quality of raw materials obtained by the company. This could be due to the indirect system of purchasing raw materials from company to farmers. Based on Elhalis et al. (2023), coffee beans could undergo fermentation and other chemical processes if raw coffee beans picked are not immediately processed for more than 8 hours.

2. Employee working hours

The high score of employee working hours can be realized due to the high demand received by the company in a particular month. Thus, the idle time of employees was much lower little due to the high intensity of company production. This is in accordance with Erdhianto and Basuki (2019), who said that the length of employee's working time influences the company's high and low productivity level. Thus, the products obtained could be higherif employees work more than their idle time.

The low score obtained was inseparable from the low demand for roasted coffee received by the company. As a result, the company's production intensity was so low, indicating a high employee idle time. Gumati (2015) stated that reducing ineffective working hours is needed to boost the company's productivity.

3. Use of electrical energy

The main aspects causing the high score on this criterion were the short total machine preparation time due to the high production intensity and the efficient lighting sources. According to Borowski (2018), energy consumption in the industrial sector is highly dependent on the company's activities during production process.

The lowest score was due to the company's low daily production intensity, but the machines are still prepared daily despite the small quantities of products produced. Lamps as a lighting source are often not turned off, even duringwith no production process was taking place. Mawson and Hughes (2019) said that reducing energy consumption in the production process can improve productivity levels and profitability.

4. Machine working hours

The quality of the raw materials affects the machine's productivity. For instance, if the raw materials used by the company are of high quality, the machine could be more productive due to the low depreciation rate, thus increasing the machine's performance. According to Ghodki and

Pandey (2021), machinery is one of the main aspects to be optimized by the company by effectively used to boost the company's productivity level.

Similarly, the lowest score was obtained due to the low quality of raw materials used in a particular month. The lack of optimal machine performance is also one of the factors affecting the low score on this criterion. According to Tarigan et al. (2013), machines can work optimally if the company can design a proper maintenance system.

Total productivity analysis

The total productivity analysis was intended to determine the productivity level obtained by PT Tinkerbels Permata Indah in producing roasted coffee based on all inputs used. The total productivity analysis is based on the monthly productivity index obtained during the measurement time span, and the results are shown in Table 10.

The company's highest index gain found in December 2022 was 261.44% due to the large current value in that month compared to the previous value or productivity of the previous month. The main factor in the high current gain in that month was the high level of demand for roasted coffee received by the company compared to the previous month. This increases the performance of all criteria used, leading to improve the acquisition of the current value. According to Fuente-Mella et al. (2020), the variables of raw materials and labor in the industrial sector significantly influence on productivity and efficiency.

The lowest productivity index of PT Tinkerbels Permata Indah was found in September 2022, at a value of -79.23. This was due to the low quality of raw materials used, the large amount of employee idle time, the inefficient electricity use, and unproperly maintained machines. According to Ayvaz and Alpay (2021), optimizing machine functions requires careful attention by implementing maintenance management to ensure that engine reliability can be continueallymaintained and operate according to its function.

said it can also be seenthat there was a significant decline in the productivity index from 94.78% in -4.12% in July 2022 to August 2022, or by total of 98.9% decrease. This trend occured due to differences in the acquisition of current and previous values between the two months. The previous July 2022 value or the current gain in June 2022 is relatively very small, only 2.269 compared to the current July 2022 of 4.42..

Proposed productivity improvements

The proposed improvementare given as a reference for the company to improve its productivity continuosly to level 10. The proposed improvement was designed based on the use of each criterion and the number of roasted coffee products produced by the company in the last measurement period, as presented in Table 11.

Table 10. PT Tinkerbels Permata Indah productivity index (Data Processed, 2023)

Period	Current	Previous	Index Productivity (%)
October 21	3.04	-	0.00
November 21	2.72	3.04	-10.74
December 21	2.86	2.72	5.22
January 22	4.01	2.86	40.33
February 22	3.93	4.01	-1.98
March 22	4.74	3.93	20.47
April 22	5.89	4.74	24.36
Mey 22	1.66	5.89	-71.77
June 22	2.27	1.66	36.45
July 22	4.42	2.27	94.78
August 22	4.24	4.42	-4.12
September 22	0.88	4.24	-79.23
October 22	1.21	0.88	37.06
November 22	1.11	1.21	-8.07
December 22	4.01	1.11	261.44

Table 11. Proposed productivity improvement of PT Tinkerbels Permata Indah (Data Processed, 2023)

No	Criteria	Last Period	Proposed Improvements	Amount of Waste	Persentace (%)
1	Raw Material (kg)	2664	2593.74	70.26	2.6
2	Employee Working Hours (hours)	288	278.44	9.56	3.3
3	Use of Electrical Energy (kWh)	312.68	295.97	16.71	5.3
4	Machine Working Hours (hours)	96.81	94.97	1.84	1.9

1. Raw material

The company needs to reduce the use of raw materials by 70.26 kg. This can be realized with several actions, which include the need for the supply of raw materials to maintain uniformity in the quality of the materials used so that low quality materials are not found when scarcity occurs. According to Saputra et al. (2021), sufficient inventory can be a way to obtain good product quality and minimize the occurrence of out-ofstock to provide a high customer's satisfaction level.

2. Employee working hours

A waste of 3.3% was found in the number of hours worked by employees. The first step that can be done is to measure work time. Another step that can be applied is to apply flexible daily hours. Indrawati and Pradhanawati (2019) reported' that this system eliminates employee's daily fixed working time and plans employee working time based on agreed agreements.

3. Use of electrical energy

The company needs to reduce waste by 5.3% through several actions, such as creating a production schedule, rearranging the layout of facilities, and fostering an energy-saving culture in employees. According to Schubert et al. (2018), another significant step in supporting the company's energy efficiency can be conducting energy audits.

4. Machine working hours

The proposed improvement to achieve level 10 productivity on the machine working hour criterion was 94.97 hours. This can be realized by implementing maintenancee management. Based on Mohan et al. (2021), activities such as engine inspection, lubrication, replacement, and repair of each component must continuosky and regularly carried out to ensure that the machine operates normally.

The calculation of the proposed amount of resource use in all four criteria was by dividing the number of roasted coffee products produced by the company in the last measurement period (2175 kg) by the level 10 value of each criterion. The amount of the proposed value obtained was then used as a reference to determine the waste that occurred in the last period. Table 11 shows the calculation resultswhich indicate waste in each criterion used. Therefore, precaution activities or programs are required should the company want to improve the productivity.

Conclusions

The highest company achievement was 5.893 in April 2022, and the lowest was 0.880 in September 2022. The highest productivity index was obtained in December 2022 at 261.44%, with the lowest in September 2022 at -79.23%. The proposed activities to enhance the company's productivity up to level 10 were to reduce waste from the four criteria of raw materials usage, employee working hours, machine working hours, and electrical energy usage by 2.6%, 3.3%, 5.3%, and 1.9%, respectively. Further in-depth study is suggested to include several other criteria, such as product quality, waste produced, and the standard time required for employees to carry out the production process.

Declarations

Conflict of interests The authors declare no competing interests.

References

Abastante, F., Corrente, S., Greco, S., Ishizaka, A., and Lami, I. M. (2019) 'A new parsimonious ahp methodology: Assigning priorities to many objects by comparing pairwise few reference objects',

Expert System with Applications, 127(1), pp. 109-120

Ayvaz, S., and Alpay, K. (2021) 'Predictive maintenance system for production lines in manufacturing: A machine leraning approach using iot data in real time', *Expert System With Applications*, 173(1), pp. 1-10

Borowski, P. F. (2021) 'Digitazition, digital twins, blockchain, and industry 4.0 as elements of management process in enterprises in the energy sector', *Multidisciplinary Digital Publishing Institute Journal*, 14(7), pp. 1-20

Deoranto, P., Harwitasari, A., and Ikasari, D.M. (2016) 'Analisis produktivitas dan profitabilitas produksi sari apel dengan metode american productivity center di KSU Brosem (Analysis of productivity and profitability of apple cider production using the American Productivity Center method at KSU Brosem)', *Jurnal Teknologi dan Manajemen Agroindustri*, 5(3), pp. 114-124 [In Indonesian]

Elhalis, H., Cox, J., and Zhao, J. (2023) 'Coffee fermentation: expedition from traditional to controlled process and perspectives for industrialization', *Applied Food Research*, 3(1), pp. 1-14

Erdhianto, Y., and Basuki, H. M. G. (2019) 'Analisa produktivitas pada PT. Perkebunan Nusantara (PTPN) X PG Kremboong dengan metode objective matrix (OMAX) (Productivity analysis at PT. Perkebunan Nusantara (PTPN) using the objective matrix (OMAX) method)', *Management Systems & Industrial Engineering Journal*, 2(2), pp. 67-75 [In Indonesian]

Fuente-Mella, H., Fuentes, J. L. R., and Leiva, V. (2020) 'Econometric modeling of productivity and technical efficiency in the Chilean manufacturing industry', *Computing and Industrial Engineering*, 139(1), pp. 1-11

Ghodki, A. K., and Pandey, J. (2021) 'Productivity improvement in manufacturing industry using work study technique' *International Journal of Science, Engineering, and Technology,* 9(1), pp 1-8

Gumanti, D. (2015) 'Hubungan jam kerja, tata ruang kantor dan pengawasan dengan produktivitas kerja pegawai badan pemberdayaan masyarakat (BPM) Kabupaten Solok (The relationship between working hours, office layout and supervision with the work productivity of Solok Regency Community Empowerment Agency employees)', *Journal of Economic and Economic Education*, 4(1), pp. 42-51 [In Indonesian]

Indrawati, A., and Pradhanawati, A. (2019) 'Peran ganda dan fleksibilitas jam kerja terhadap produktivitas kerja perempuan pada ukm konveksi batik Semarang 16 (The dual role and flexibility of working hours on women's work productivity in Semarang batik convection SMEs 16)', *Jurnal Ilmu Administrasi Bisnis*, 8(4), pp. 1-9 [In Indonesian]

Irwansyah, D., Erliana, C. I., Fadlisyah., Ula, M., Fahrozi, M., and Harun. R. (2022) 'Increasing productivity in cpo production using the objective matrix (OMAX) method', *International Journal of Engineering, Science, and Information Technology*, 2(2), pp 14-20

Lesmana, S. A., Junaedi, D., and Triana N. E. (2020) 'Productivity analysis in assembly department using objective matrix (OMAX) method in labor intensive manufacturing', *Internation Journal of Engineering Research and Advanced Technology* 6(7), pp. 1-9 [In Indonesian]

Luhulima, R. B., Tukan, M., Hutapea, G., and Napitupulu, H. (2022) 'Analysis the efficiency and productivity measurement of pt mariana Bahagia shipyard using omax method', *International Journal of Progressive Sciences and Technologies*, 35(1), pp. 326-333

Mawson, V. J., and Hughes, B. R. (2019) 'The development of modelling tools to improve energy efficiency in manufacturing processes and systems', *Journal of Manufacturing System Elsevier*, 51, pp. 95-105

Mohan, R. T., Roselyn, P. J., Uthara, A. R., Devaraj, D., and Umachandran, K. (2021) 'Intelligent machine learning based total productive maintenance approach for achieving zero downtime in industrial machinery', *Computers & Industrial Engineering*, 157, pp. 1-22

Munthafa, A.E., and Mubarok, H. (2017) 'Penerapan metode analytical hierarchy process dalam sistem pendukung keputusan penentuan mahasiswa berprestasi (Application of the analytical hierarchy process method in the decision support system for determining outstanding students)', *Jurnal Siliwangi*, 3(2), pp. 192-201 [In Indonesian]

Nurwantara, M. P., Deoranto, P., and Effendi, M. (2018) 'Productivity analysis of coffe production process with objective matrix (OMAX) method (the case study at PT. Perkebunan Kandangan, Pulosari Panggungsari, Madiun)', *SEAS (Sustainable Environment Agricultural Science)*, 2(1), pp. 18-26

Odu, G. O. (2019) 'Weighting methods for multi-criteria decision making technique', *Journal of Applied Sciences and Environmental Management*, 23(8), pp. 1449-1457

Priangga, P., and Suryani, E. (2019) 'Decision analysis of giving credit using pairwise comparisons and scoring methods (Case study : Bank XYZ)', *The Journal for Technology and Science*, 30(1), pp. 1-6

Saputra, W. S., Ernawati, R., and Wulansari, W. A. (2021) 'Anaysis of raw material inventory control using economic order quantity (EOQ) method at CV. XYZ', *International Journal of Computer and Information System*, 2(3), pp. 118-124

Satar, M., Israndi, A. (2019) 'Pengaruh kualitas bahan baku dan efisiensi biaya produksi terhadap kualitas produk pada CV. Granville (The influence of raw material quality and production cost efficiency on

product quality at CV. Granville)', *Jurnal Ilmiah Akuntansi*, 10(3), pp. 89-101 [In Indonesian]

Sayuti, M., Pratiwi A. I., and Triana, N. N. (2021) 'Measurement and analysis of productivity in the process of raw material shearing sheet by using matrix objective', *IOP Conference Series*: *Material Science and Engineering*, 10(34), pp. 1-10

Schubert, T., Breitschofp, B., and Plotz, P. (2021) 'Energy efficiency and the direct and indirect effect of energy audits and implementation support programmes in germany', *Energy Policy Elsevier*, 157, pp. 1-11

Sentosa, E., and Trianti, E. (2017) 'Pengaruh kualitas bahan baku, proses produksi dan kualitas tenaga kerja terhadap kualitas produk pada PT Delta Surya Energy di Bekasi (The influence of raw material quality, production process and labor quality on product quality at PT Delta Surya Energy in Bekasi)', *Jurnal Ilmu Manajemen*, 13(2), pp. 62-71 [In Indonesian]

Tarigan, P., Ginting, E., and Siregar, I. (2013) 'Perawatan mesin secara preventive maintenance dengan modularity design pada PT. RXZ (Machine maintenance is preventive maintenance with modularity design at PT. RXZ)', *Jurnal Teknik Industri FT USU*, 3(3), pp 35-39 [In Indonesian]

Winingsih, T. R., and Septiani, Y. (2022) 'Indonesian coffee export analysis to Germany from 1990 to 2019', *AFEBI Economic and Finance Review*, 7(1), pp. 73-81