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Application of Economic and Mathematical Methods and Models in Personnel Performance Control Practice in Indonesia (Study Case PT. Harapan Jaya Multibisnis)

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A B S T R A C T

The manufacturing industry is a complex sector that requires control over each of its resources, one of which is human resources. One of the indicators that can be used to control human resources is by calculating productivity efficiency. In this study, productivity efficiency was carried out using the Cobb-Douglass production function approach method on the example of the company PT Harapan Jaya Multibusiness. The results of the analysis showed that during the period January-October 2023 the value of productivity efficiency achieved was 15% which indicated low productivity efficiency. After further investigation of the causes of low efficiency, we found two indicators that are the main causes of low productivity efficiency, namely the t-start value of capital expenditure of -23.9871 and p-value of 87%. The low t-start value indicates that the sales ratio is not directly proportional to the cost of capital invested or the cost of capital investment. At the same time, the high p-value indicates that excess labor is involved in the production process.

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INTRODUCTION

The manufacturing industry is a complex sector that requires control over each of its resources. If control over resources is only in one part, it can cause losses such as losses to the company and losses to the workforce itself (Health Assured team, 2021). According to research conducted to analyse the factors of company losses due to mismanagement, it was found that one of the triggers was human resource management, which most often triggered company losses (Ashley, 2019).

One of the methods used in human resource management in the manufacturing industry is the use of mathematical modeling techniques. This method can be used in human resource management practices in the industry to optimize human resource allocation and minimize costs. The advantage of this method is that it can guarantee the objectivity of evaluation through mathematical analysis of outcome variables, making it easier for project managers to make decisions related to human resource control.

An alternative option for applying the economic-mathematical model method to construction projects is to conduct a labor productivity analysis. This analysis is carried out using several variables, such as the results of field observations of certain types of work, then the data is analyzed using certain coefficients and compared with locally applicable reference standards. Thus, the purpose of this research is to try to analyze personnel control in construction projects using the economic-mathematical method using a case study at Harapan Jaya Multibisnis, a pipe manufacturing company located in Makassar, Indonesia.

THEORETICAL REVIEW

Labor Productivity

A number of personnel management strategies are required to optimize personnel control. One strategy to optimize personnel control can use a performance management approach to personnel cost performance. Analysis of the efficiency of measuring personnel cost performance can use 3 approaches (Will, 2022), namely:

1. Cost-benefit ratio
2. Analyzing the state of the economic system or qualitative characteristics of management
3. Level of approximation to the optimal state of the economic system

Based on these three approaches, there are several indicators that can be used to identify factors and analyse the efficiency of personnel costs, such as:

- Labor productivity
- Annual economic aspects
- Financial economy
- Staff turnover rate

In this journal, the analysis will be conducted using two efficiency approaches, namely the cost-benefit approach and the optimal economic system approach, using labor productivity and production efficiency measures. In simple terms, productivity can be defined as the ratio of output to input, which

can be represented as the following equation (Will, What Is Productivity and How to Measure It, 2022):

$$Performance = \frac{Product\ manufactured}{input(working\ hours)} \qquad (1)$$

From the equation, we can see that the output produced can be the result of what labor does, such as the amount or volume of work done, while the input in the equation is the amount of labor involved in the work process. Labor productivity.

A measure of labor productivity that only considers one of the inputs is called single-factor productivity, while a measure of productivity that includes many input variables is called multi-factor productivity or total factor productivity, which can be written as follows:

$$Multyfactor\ Productivity = \frac{output}{labor + material\ energy + capital + miscellaneous} \text{..... (2)}$$

Productivity is interrelated with production efficiency. Production efficiency can be defined as an economic term that describes the level at which an economy or organization can no longer produce additional quantities of a good without reducing the productivity levels of others (Wenrong, Tao, Zhuwang, & Lisha, 2022). Production efficiency can be defined as the maximum capacity level at which all resources are fully utilized to produce output at the lowest cost. Production efficiency is also often referred to as production efficiency, which can be interpreted as operating a business at its maximum capacity.

There are many ways to measure production efficiency. One of the most commonly used formulas to measure efficiency is to divide the output by the standard output level and multiply it by 100 to get a percentage. This calculation can be used to analyze the efficiency of a worker, a group of workers, or part of the economy as a whole, and the mathematical equation can be written as follows:

Production efficiency = *output level - standart output level* × *100*..... (3)

The standardized production rate reflects the maximum level of productivity or the maximum amount of work performed per unit of time using standardized methods. When maximum production efficiency is achieved for each sample analyzed, production efficiency reaches 100%. If the economy is producing efficiently, then production efficiency reaches 100%.

If we look at the efficiency formula, we see that production efficiency is closely related to output. We can also say that this efficiency is a share of output, which is the total amount of useful work done, excluding the factors of waste and spoilage (THE INVESTOPEDIA TEAM, 2020). Since production efficiency is closely related to output, we can say that production efficiency is correlated with output itself.

One of the functions of productivity measurement is to measure output, which is usually expressed in units of time. Besides being related to the number of units produced, production efficiency is also often related to the cost of producing one unit of output. One method of measuring productivity and production efficiency can involve economies of scale analysis, where companies seek to optimize production levels to achieve efficient economies of scale that help reduce production costs per unit and increase profits per unit.

fungsi Cobb-Douglas

we use the Cobb-Douglas function method of production efficiency to measure production efficiency or, as it is often called, labor productivity efficiency based on a number of production variables. The Cobb-Douglas function method was first developed by Cobb and P.H. Douglas in 1928 and published in the same year in the American Economic Review (Caroline, 2023). This method uses a function equation approach, which can be written as follows (Ahfazh, Elis, Asep, Sudradja, & Subiyanto, 2018):

$$Q = f(K, L) = AK^{\alpha}L^{\beta} \quad \text{.....(4)}$$

Q dalam persamaan tersebut adalah total output, yang satuannya tergantung pada waktu pengukuran. K adalah belanja modal, yang merupakan total investasi dalam produksi perusahaan dalam bentuk aset tetap. Selain itu, L adalah total kontribusi pekerja yang dipekerjakan selama periode pengukuran. Simbol A dalam persamaan ini sering disebut sebagai produktivitas faktor konstan atau produktivitas faktor total. Parameter α dan β menunjukkan tingkat elastisitas output tenaga kerja dan input modal. Elastisitas output ini mengukur sensitivitas output terhadap perubahan tingkat tenaga kerja dan modal yang digunakan dalam produksi.

METHODOLOGY

The Cobb-Douglas function method is a complex mathematical and economic calculation method that requires high accuracy in the calculation process. To reduce the risk of miscalculation in the measurement process, innovative technological approaches can be used to develop, justify, and make staffing decisions. The measurement of performance efficiency by the Cobb-Douglas function method uses a large amount of statistical data in its calculation. Therefore, with the help of innovative technology, two applications namely Microsoft Excel and SPSS can be used in performing calculations.

Productivity efficiency analysis using the Cobb-Douglas approach requires a number of data variables such as capital output, labor input, and total output variables. Case example of Harapan Jaya Multibusiness using the latest production data from January to October 2023.

- ***Gross profit calculation***

Gross profit is calculated to get the value of cost selectivity to production results. The calculation in the example of Harapan Jaya Multibusiness is done using the following formula:

Gross profit = Total output × Price.....(5)

Gross profit in this equation can be interpreted as the total gross revenue of the company. Total output is the total number of products produced by a single machine during the observation period, and price is the price of production, which depends on the diameter of the pipe produced.

- ***Labor Price***

Calculation of labor prices is carried out to determine the level of selectivity of employee costs. The calculation of the price of labor at Harapan Jaya Multibusiness is done by multiplying the wage and the number of workers.

price = Number of employees x wages.....(6)

- ***Capital Injection***

Calculation of return on capital is done to determine the level of net profit of production. The calculation of capital efficiency at Harapan Jaya Multibusiness is done using the following formula:

$Capital\ input = production\ investment - (gross\ profit \times profit\ planning)$ – *labor price*.....(7)

Production investment in this equation is defined as the investment cost of machinery and profit planning is the amount of net profit planned by the company. In the example of Harapan Jaya multi-product company, the net profit per month is planned to be 7% of the total production.

Based on the analysis results of gross profit, labor price and capital cost, all data are converted to natural logarithm.

Natural logarithm transformation is usually used by researchers to convert exponential functions into linear form. The transformed equation using natural logarithm is as follows (Kanda Data, 2023)

ln (Y) = ln (a) + b1Ln(X1) + b2Ln(X2) + e .....(8)

However, if the formula needs to be adjusted to account for the calculation variables obtained, the formula can be written as follows:

$\ln(Q) + \propto \times \ln(L) + \beta \times \ln(K)$.....(9)

The conversion of data to natural logarithms is done to simplify estimation and analysis, which facilitates the application of statistical techniques such as least squares regression. In addition, conversion to natural logarithms is used to maintain homogeneity of the production function to ensure that changes in inputs and outputs are consistent with their respective elasticities, and to improve the statistical properties of the model, such as reducing heteroscedasticity and improving the properties of the error distribution. (Kanda Data, 2023)

RESULTS

The results of the gross profit formula calculation are as follows :

Table 1. Gross Profit

Month	Gross Profit
1	Rp 16.530.489.350,00.
2	Rp 14.239.361.450,00.
3	Rp 21.776.851.050,00.
4	Rp 14.782.460.050,00.
5	Rp 17.105.464.300,00.
6	Rp 24.331.821.900,00.
7	Rp 25.530.722.800,00.
8	Rp 32.976.143.450,00.
9	Rp 26.060.193.800,00.
10	Rp 24.850.006.000,00.

Based on the results of the gross profit calculation, it can be seen that the highest gross profit was obtained in August and the lowest gross profit was obtained in February.

The results of the calculation of variable labor prices are as follows:

Table 2. Labor Price

Month	Labor Price
1	Rp 26.200.000,00
2	Rp 26.200.000,00
3	Rp 26.200.000,00
4	Rp 26.200.000,00
5	Rp 26.200.000,00
6	Rp 39.300.000,00
7	Rp 39.300.000,00
8	Rp 39.300.000,00
9	Rp 39.300.000,00
10	Rp 39.300.000,00

From the data obtained, it is known that the amount of labor issued has not decreased, but there is an increase in labor in June 2023, this can be seen from the increase in the price value of labor in that month. The results of the capital investment calculation can be seen in the following table:

Table 3. Capital Investment

Month	Capital Input
1	Rp 16.860.218.885,50.
2	Rp 14.729.469.938,50.
3	Rp 21.739.335.266,50.
4	Rp 15.234.551.636,50.
5	Rp 17.394.945.589,00.
6	Rp 24.102.358.157,00.
7	Rp 25.217.335.994,00.

8	Rp 32.141.577.198,50.
9	Rp 25.709.744.024,00.
10	Rp 24.584.269.370,00.

From the calculation of capital return, it is known that the highest level of net profit is in August 2023 and the lowest level of net profit is in February 2023. The natural logarithm transformation calculation is carried out as follows:

- ***Natural logarithm of gross profit***

  Gross profit conversion to natural logarithm is done to get the amount of gross profit. The calculation results are presented in the following table:

Table 4. Basic Logarithm of Gross Profit

Month	Gross Profit	Log Data Gross Profit
1	Rp 16.530.489.350,00.	Rp 23,53.
2	Rp 14.239.361.450,00.	Rp 23,38
3	Rp 21.776.851.050,00.	Rp 23,80.
4	Rp 14.782.460.050,00.	Rp 23,42
5	Rp 17.105.464.300,00.	Rp 23,56.
6	Rp 24.331.821.900,00.	Rp 23,92
7	Rp 25.530.722.800,00.	Rp 23,96.
8	Rp 32.976.143.450,00.	Rp 24,22
9	Rp 26.060.193.800,00.	Rp 23,98
10	Rp 24.850.006.000,00.	Rp 23,94

- ***Natural logarithm conversion of labor price***

  Logarithmic transformation is also carried out for the labor price variable. Conversion of labor price to natural logarithm is done to get the natural number of labor price. The calculation results can be seen in the following table:

Table 5. Data log harga tenaga kerja

bulan	harga tenaga kerja	data log laba kotor
1	Rp 26.200.000,00	Rp 17,08.
2	Rp 26.200.000,00	Rp 17,08.
3	Rp 26.200.000,00	Rp 17,08.
4	Rp 26.200.000,00	Rp 17,08.
5	Rp 26.200.000,00	Rp 17,08.
6	Rp 39.300.000,00	Rp 17,49
7	Rp 39.300.000,00	Rp 17,49
8	Rp 39.300.000,00	Rp 17,49
9	Rp 39.300.000,00	Rp 17,49
10	Rp 39.300.000,00	Rp 17,49

- ***Logarithm conversion of contribution to natural capital***

  Conversion to logarithm was also done for the capital output variable. The transformation of the natural logarithm of capital output was done to obtain a non-natural number for the variable. The calculation results can be seen in the following table:

Table 6. Logarithm of capital productivity

Month	Capital Input	Capital input Log Data
1	Rp 16.860.218.885,50.	Rp 23,55.
2	Rp 14.729.469.938,50.	Rp 23,41.
3	Rp 21.739.335.266,50.	Rp 23,80.
4	Rp 15.234.551.636,50.	Rp 23.45.
5	Rp 17.394.945.589,00.	Rp 23,58.
6	Rp 24.102.358.157,00.	Rp 23,91.
7	Rp 25.217.335.994,00.	Rp 23,95.
8	Rp 32.141.577.198,50.	Rp 24,19.
9	Rp 25.709.744.024,00.	Rp 23,97
10	Rp 24.584.269.370,00.	Rp 23,93

Based on the results of the conversion of the numbers of each variable into the natural logarithm, the following calculations are carried out - finding the value of the regression coefficient and finding the value of the natural logarithm of productivity efficiency. The following formula is used to do the calculation:

$$y = mx + c \quad (10)$$

Where:
Y = Independent variable;
X = dependency variable
M = gradient of the line
C = intersection of axes

To simplify the measurement, the calculation was done in Microsoft Excel using the LINEST formula. Based on the results of data processing, the regression coefficient values and standard errors of output and input elasticities are

presented in the following table:

Table 7. Perhitungan nilai regresi

	β	α	ln(A)
koefisien	1.077849353	0.001349	-1.876772682
standar kesalahan	0.006686833	0.008165	0.078240812

The results of the regression coefficients and standard errors are then processed again to determine the t value and p value. T-start is a statistical measure used to determine the significance of a coefficient in a statistical model. In general, the T-start formula can be written as follows (Hülya, 2021):

$\frac{\partial Y}{\partial L} = \mathrm{A}\alpha L^{\alpha-1}\mathrm{K}^{\beta}$.....(11)

If the t-start formula wants to be simplified, the t-start formula can be written with the following formula:

$t - start = \frac{(coeficient - nilai\ hipotesis\ null)}{Standard\ error}$.....(12)

Table 8. Control calculation

	Gross Profit	Labor Pricre	Capital Input
T-start	161.1898048	0.165224	-23.98713188
P-Value	0%	87%	0%

If we look at Table 8, besides the t-start value, there is also a p-value there. The p-value is a statistical measure used to test the null hypothesis in regression analysis. The p-value provides information on how strong the evidence is in favor of or against the null hypothesis. The null hypothesis in this context is that the regression coefficient is zero or insignificant. If the p-value is less than the specified significance level (usually 0.05), the null hypothesis is rejected and we conclude that the regression coefficients are statistically significant. If the p-value is greater than the significance level, then the null hypothesis is accepted and we do not have sufficient evidence to conclude that the regression coefficients are statistically significant. The p-value can be calculated using various statistical methods such as t-test or F-test. The choice of method depends on the context of the regression analysis and the objectives of the study. To calculate the p-value, a two-point Student t-score distribution function is used. This function can be used to calculate the probability or percentage of a particular value with a two-point t-score distribution. The T.DIST.2T formula in Microsoft excel is used to facilitate the calculation.

After the natural logarithm results were obtained, total factor productivity was calculated to determine the company's productivity efficiency

level per month. The calculation is done by deriving the general formula of the Cobb-Douglas function as follows:

$$Q = f(K, L) = AK^{\alpha}L^{\beta} \quad (13)$$

$$A = \frac{Q}{L^{\beta} \times K^{\alpha}}$$

The results of the calculation of overall performance efficiency can be seen in the following table:

Table 9. total factor productivity efficiency

Month	total efficiency factor productivity
1	0.1532
2	0.1527
3	0.1535
4	0.1528
5	0.1533
6	0.1533
7	0.1532
8	0.1524
9	0.1532
10	0.1533

DISCUSSION

By analyzing the data, it can be seen that there are several factors that affect performance efficiency in the case of Harapan Jaya Multibusiness, namely :

- ***Management Factor***

Based on the results of calculations using the Cobb-Douglas function in calculating the level of productivity efficiency, one of the factors that affect the level of productivity efficiency is management factors. Management factors affect the calculation because management is responsible for determining how many machines or how many workers are needed to produce one unit of output. In the case of Harapan Jaya Multibusiness, management increased the number of workers in June. This increase in the number of workers affects the variables in the calculation such as the variable price of labor and the elasticity of output to labor.

- ***Sales Factor***

In addition to sales factors, sales factors also affect productivity efficiency results. In the Harapan Jaya Multibusiness case, the sales factor affects the gross profit variable and the capital expenditure variable. If sales are too low, it will cause a decrease in productivity efficiency, which can also be interpreted as an economic loss for the company.

- ***Labor Factor***

Labor factors also affect productivity efficiency. In the calculation of the Cobb-Douglas function, wages and the amount of labor affect the labor price variable and the value of the elasticity of labor to output. In addition to affecting these variables, the labor factor also affects the control t-value and p-value.

- ***Net Income Factor***

The last factor determined from the Cobb-Douglas function analysis is the net income factor. The net income factor referred to in this case study is the percentage of the company's planned net income in that month. In the example of Harapan Jaya Multibusiness, net income affects the input variables which in turn will affect the value of the regression coefficient and control calculation as well as the percentage value of the performance efficiency level.

CONCLUSIONS AND RECOMMENDATIONS

Based on the measurement of productivity efficiency using the Cobb-Douglas function method and the recommendations that have been made, we conclude that labor control in Harapan Jaya Multibusiness is not effective. The reason why we found that labor control in Harapan Jaya Multibusiness is not effective is because the productivity efficiency value is only around 0.15 or if expressed in percentage form is 15%. Based on the percentage value, we found 2 main indicators that cause inefficient productivity in the company. The two indicators are the negative indicators found when calculating the control t-start on capital performance -23.9871. This indicates that the target output is not directly proportional to the rate of return on capital investment. Production volume depends on sales volume, so based on the developed recommendations, we recommend increasing the number of personnel in the sales department.

Second, we also estimate that the number of workers in the production department is inefficient. This can be seen from the high P-value of 87% in the benchmark calculation. Thus, based on this result, we recommend reducing the number of workers in the production department and conducting staff assessment and training.

FURTHER STUDY

In further studies using the Cobb-Douglas production function, exploring variations in the coefficients of the Cobb-Douglas function across different industries or regions may provide valuable insights into the efficiency and productivity dynamics in specific sectors other than the plants examined in this study. In addition, the linear form of the Cobb-Douglas production function model may oversimplify complex production processes and fail to capture nonlinear relationships that can significantly impact production levels. Therefore, in addition to the Cobb-Douglas production function, other methods should also be used as a complement to control the performance of personnel.

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