Application of Craig Harris and fuzzy analytical hierarchy process methods to improve chicken farming productivity at Jimmy's farm

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Abstract: Chicken farming, as part of the agricultural sector, is developing in Indonesia, leading to a high level of competition. Jimmy's farm is one of the poultry farms that manage the breeding, hatching and raising of chickens. The problem faced by these farms is the absence of productivity measurements that result in a lack of competitiveness of farms. This study aims to measure the level of productivity of farms using the Craig Harris method, analysing the causes of decreasing productivity using the Fishbone diagram and proposing increased productivity using the Fuzzy - Analytical Hierarchy Process (AHP). Based on productivity measurements using the Craig Harris method, the lowest total productivity value was obtained in May 2019 with a value of 0.66. That is due to an increase in feed purchases and energy consumption. Meanwhile, the highest total productivity value was found in March 2019 with a value of 1.22 due to the high level of market demand. The fishbone diagram analyses problems in labour factors and energy utilisation as the leading causes of decreasing productivity. Meanwhile, the proposed improvement using fuzzy AHP that can be applied is to make energy-efficient movements, periodic control, counselling, and modification of the incubator.

1. Introduction
Poultry farming in Indonesia has an essential role in the development of the livestock industry, especially in fulfilling the needs of animal source foods. The increase in the income of the Indonesian people can also increase the level of consumption of animal protein ingredients.

Jimmy's farm is a chicken farm in Cipanas, Cianjur Regency, West Java, Indonesia. This company can produce approximately 6,000 to 7,000 eggs each week and can produce 28,000 - 30,000 a-day-old chickens (DOC) per month. Currently, Jimmy's Farm does not have a tool to measure the productivity and the production quantities of the chickens. The farm's performance is fluctuated due to several factors such as climate and weather, diseases, types of animal feed and vaccines consumed by the chickens, as well as cage density. As a consequence, it is necessary to measure the productivity value to measure the performance of the farm.

Productivity is the ratio between output and input where output is the revenues, while input is the production resources [1]. Increased productivity is carried out by maximising the use of production resources. Productivity can be used as an indicator of a company efficiency is in mixing its existing resources. Productivity measurement is also essential to maintain company performance [2].
of productivity at Jimmy's Farm can be the cornerstone in determining the direction of future productivity improvements that can also be employed as a profitability monitoring tool.

Several types of methods can be used in measuring productivity, i.e. objective matrix (OMAX), POSPAC, Multi-Factor Productivity Measurement Model (MFPMM) and Craig Harris [3]. The productivity measurement model with the Craig Harris method refers to the measurement of total productivity which can describe the level of efficiency and growth of the company as a whole by assuming that the company goals are oriented towards maximum profit [4]. This research measures total productivity in the livestock sector, which was suitable using Craig Harris. Cause effect diagram (fishbone) is used to analyse the factors that affect productivity. In addition, the AHP method is used to select the best recommendations for improvements aimed at the company with fuzzy logic which is expected to increase productivity for the company. The addition of fuzzy logic to AHP produces alternative suggestions for company improvement that contain elements of fuzziness, uncertainty, and truth [5].

2. Research Methods

The method used in this research is quantitative descriptive method. Quantitative descriptive method is a research method for problem-solving by describing a company as a whole combined with methods for processing and interpreting data. The quantitative descriptive method used was productivity measurement with Craig Harris and Fuzzy Analytical Hierarchy Process (F-AHP) methods as well as a description of the conditions of the farm.

The research stages were as follows:

2.1. Preliminary survey
The preliminary survey aims to ascertain the company profile, background and management applied by the company.

2.2. Literature study
Literature study aims to discover similar studies and their theoretical basis.

2.3. Data collection
This study used two types of data,

a. Primary data, obtained by observation, interviews, documentation, and questionnaire distribution.

b. Secondary data, obtained from Jimmy's Farm documents and records in the form of financial reports.

The required data were those related to the criteria used in measuring productivity, which includes the input and output of the farm.

2.4. Validity test
The validity test was carried out using the face validity method, which is a decision whether the instrument in question has measured the corresponding concept [6].

2.5. Data analysis
Some of the methods used for the analysis of Jimmy's Farm productivity were:

a. Craig Harris method
The analysed data were processed through a calculation with a formula by dividing the total output to total input [7]. The formula of productivity level calculation is as follows:

\[
P_t = \frac{Q_t}{L+C+R+Q}
\]

Where :

- \(P_t\) = Total Productivity
- \(Q_t\) = Total Output (In Rupiah)
- \(L\) = Labor Input (In Rupiah)
C = Capital Input (In Rupiah)
R = Raw Material input (In Rupiah)
Q = Miscellaneous Input (In Rupiah)

b. Fishbone method
The fishbone method in this study aims to determine the problems that caused a decrease in productivity in the calculation of partial productivity [8].

c. Fuzzy Analytical Hierarchy Process (F-AHP)
The steps of the F-AHP method, according to [9] are as follows:
1) Determine the pairwise comparison matrices between the criteria with TFN scale.
2) Determine the Eigenvalues and Eigenvectors
In AHP calculations, the largest eigenvalues are expressed by $\lambda_{\text{maximum}}$ for a consistent matrix. The calculation of $\lambda_{\text{maximum}}$ is intended to minimise the occurrence of inconsistent matrices due to the presence of human elements as respondents and decision-makers who cannot always be absolute and consistent in assessing or expressing assessment preferences for individual elements.
3) Determine the consistency
The inconsistency occurring in the assessment of a decision may be still likely to take place [10]. A deviation in the eigenvalue can show it. Pairwise comparisons will be categorised as consistent if the value of the CR (Consistency Ratio) calculation is $\leq 10\%$. If the calculation of the CI (consistency Index) value is 0, then the matrix form is declared consistent. The method of setting the limit for the inconsistency of the CR value is determined by using the CR value, i.e. the comparison of RI (random index) index value with the consistency index value. The determination of the limit is observed using the number of n matrix orders used.
4) Determine the value of fuzzy synthesis (Si)
Determining the weight of each element to determine the weight of the criteria or sub-criteria and the alternatives can be carried out using pairwise comparison matrices obtained from the comparison between criteria and sub-criteria. The comparison value is used for inversed comparison, which is the $a_{ij}$ value, where the $a_{ij}$ menu value shows the importance level of the i or the j element.
5) Determine the Vector Value and Defuzzification Value
If the results obtained for each fuzzy matrix are $M2 \geq M1$ ($M2 = (l2, m2, u2)$ and $M1 = (l1, m1, u1)$), then the vector value can be formulated as follows:
\[
\begin{cases}
1, & \text{if } m2 \geq m1, \\
0, & \text{if } l1 \geq u2, \\
(l2 - u2) / (m2 - m1), & \text{others}
\end{cases}
\]
(2)

If the result of fuzzy value is greater than k, $m_1$ (i=1,2,k), then the vector value can be defined as the following:
\[
V \left( m \geq m_1, m_2, \ldots, m_k \right) = V \left( m \geq m_1 \right) \text{ and } \\
V \left( m \geq m_2 \right) \text{ and } V \left( m \geq m_k \right) = \min V \left( m \geq m_i \right)
\]
(3)

By assuming that,
\[
d' \left( A_i \right) = \min \left( S_i \geq S_k \right)
\]
(4)

for $k = 1,2,\ldots,n$ ; $k \neq i$, then the vector weight value is obtained as the following:
\[
W' = (d' \left( A_1 \right), d' \left( A_2 \right), \ldots, d' \left( A_n \right))^T
\]
(5)

6) Normalise Fuzzy vector weight values (W)
If the weight vector mentioned above is normalised, the definition of the weight vector will be obtained as follows:

\[ W' = (d'(S1), d'(A2), \ldots, d'(An)) \]  

(6)

The normalised value can be obtained with the following formula:

\[ d(An) = \frac{d'(An)}{\sum_{i=1}^{n} d'(An)} \]  

(7)

3. Results and Discussion

The results of this study are as follows:

3.1. Total productivity

Table 1 shows the measurement of the total productivity of Jimmy’s Farm.

| Month    | Output    | Input       | Productivity (%) | Productivity change |
|----------|-----------|-------------|------------------|---------------------|
| January  | 332,949,350 | 450,490,770 | 0,74             | -                   |
| February | 480,925,450 | 505,283,737 | 0,95             | 0,21                |
| March    | 703,668,450 | 578,235,462 | 1,22             | 0,27                |
| April    | 645,365,300 | 645,621,703 | 1,00             | -0,22               |
| May      | 471,797,700 | 711,800,363 | 0,66             | -0,34               |
| June     | 364,419,100 | 307,941,155 | 1,18             | 0,52                |
| July     | 369,139,100 | 406,340,210 | 0,91             | -0,27               |
| August   | 352,721,800 | 295,037,366 | 1,20             | 0,29                |
| September| 358,163,000 | 443,962,074 | 0,81             | -0,39               |
| October  | 346,763,700 | 481,104,090 | 0,72             | -0,09               |
| November | 484,952,800 | 440,200,770 | 1,10             | 0,38                |
| December | 389,663,900 | 474,214,620 | 0,82             | -0,28               |

The lowest total productivity was 0.66 in May 2019, characterised by a decrease in the productivity of 0.34. This occurred due to the high input costs that were not proportional to the output produced that month. The lowest total productivity result during this measurement period was influenced by the results of partial productivity measurements, which was the input of raw materials. The low productivity value in May occurred as a result of the high costs incurred by Jimmy’s Farm to purchase chicken feed to stock up in anticipation of feedstock outages due to suppliers closing during an Islamic holiday. In May 2019, there was a high demand for chicken feed, namely the Gold Coin 201C. In May, there was also the highest sales of eggs throughout 2019. This shows that there was a large stock of laying hens being farmed by Jimmy’s Farm to produce these chicken eggs. With the high number of laying hens that were being raised to produce chicken eggs in that month, this was directly proportional to the amount of chicken feed required for the operational needs of the farm.

The highest total productivity was 1.22 in March 2019, characterised by an increase in the productivity of 0.27. This occurred due to the low input costs that were proportional to the output produced that month. The highest total productivity result during this measurement period was
influenced by the results of the partial productivity measurement, which was the output of the farm. In March, there was an increase in chicken egg production, and the success rate of hatching eggs was also relatively high.

3.2. Identification of productivity problems

The next step was to identify the problem to determine the causes of a decrease or increase in productivity using a fishbone diagram.

![Fishbone Diagram of Jimmy's farm productivity fluctuation](image)

*Figure 1. Fishbone diagram of Jimmy's farm productivity fluctuation.*

The problems occurring in the labour factor was related to lack of awareness and control of the work in gas usage economically. Another problem factor in labour was the absence of written guidelines regarding the guidance for providing chicken feed that was easy for the farmworkers to understand. Meanwhile, the problem with energy input occurred because of the high consumption of electricity in the egg hatchery and energy-saving movement that was not implemented yet.

3.3. Productivity increase planning

After perceiving the proposed improvements to increase productivity at Jimmy's Farm using a fishbone diagram, several suggestions were possible to be implemented on this farm. The determination of the increase in productivity can be carried out using the AHP fuzzy method. The proposed improvements to Jimmy's Farm productivity were carried out by conducting interviews and brainstorming with the general manager, discussing the possible improvement on productivity. An overview of the AHP fuzzy method in Jimmy's farm can be observed in Figure 2.

![Hierarchy of proposed improvements to Jimmy's farm productivity](image)

*Figure 2. The hierarchy of proposed improvements to Jimmy's farm productivity.*
The calculation of the weight of the Jimmy's Farm productivity improvement proposal was carried out using the AHP fuzzy method. The weight of the proposed improvement criteria was used as the input in calculating the aggregate.

Table 2. The results of calculations using the AHP method regarding the weight of proposed productivity.

| Respondents | Lambda max | CI   | CR   |
|-------------|------------|------|------|
| 1           | 5.19       | 0.047| 0.04 |
| 2           | 5.34       | 0.09 | 0.08 |

The calculation results using AHP method from the respondent one obtained a CI value of 0.047 and a CR value of 0.04, while the calculation results of respondent 2 obtained a CI value of 0.09 and CR of 0.08. The obtained CI value showed a consistent value because of the results of the processed calculation by expert values that were close to 0. The CR value showed that the results of filling out the questionnaire were classified as good because the value obtained was ≤ 0.1. Therefore, there was no necessity to refill the questionnaire. After the calculation of the weight of the proposed productivity at Jimmy's Farm completed, the next step was to calculate using fuzzy AHP as an additional method.

Table 3. Calculation of the weight and rating of proposed productivity improvement aggregates.

| Solution | The value of the aggregate calculation solution | Rank |
|----------|-----------------------------------------------|------|
| TK 1     | 0.18                                          | 4    |
| TK 2     | 0.22                                          | 3    |
| M 1      | 0.02                                          | 5    |
| E 1      | 0.32                                          | 1    |
| E 2      | 0.27                                          | 2    |

The first rank was the proposal regarding energy saving (E1) followed by regular supervision and control of energy use for home employees (E2). The third recommendation was to increase the efficiency and effectiveness of chicken feed provision (TK2) by providing written guidelines that are easy to understand for its workers. The fourth-ranked proposal concerns increasing workers' awareness of energy savings (TK1). Finally, the fifth suggestion is to modify the egg incubator (M1) as an effort to minimise the use of electricity for operations in producing chicks.

4. Conclusions
Based on productivity measurements using the Craig Harris method, the lowest total productivity was obtained in May 2019 at 0.66. That is due to an increase in feed purchases and energy consumption. Meanwhile, the highest total productivity was found in March 2019 at 1.22 due to the high level of market demand. The fishbone diagram shows that the problems in labour factors and energy utilisation were the leading causes of decreasing productivity. Meanwhile, the proposed improvement using fuzzy AHP that can be applied is to make energy-efficient movements, periodic control, counselling, and modification of the incubator.
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