A PRODUCTIVITY ANALYSIS IN WOODEN DOOR INDUSTRY BASED ON SMALL GROUP ACTIVITIES

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ABSTRACT

LENA PUSPITA SARI.  A Productivity Analysis in Wooden Door Industry Based on Small Group Activities. Supervised by TAUFIK DJATNA

The measurement of the Small Group Activities (SGA) toward employees productivity is required to see the extent of efficiency. In fact, not all of industries and employees know what the purpose of application of SGA in industries. Identification of parameters for SGA implementation was derived from employees opinion through interview which led to determine the most impactful factors. In order to measure the efficiency of SGA implementation was constructed by Data Envelopment Analysis (DEA) formulation with constant return to scale (CCR) model and output oriented. The uncertainty exists in human thinking and judgment in conjunction efficiency of SGA implementations, a Fully Fuzzy formulation implementation of DEA models solved such efficiency level as similar as point of view. The main feature of this proposed model fully fuzzy is that it is capable to consider three situations as in the problems with uncertainty and solved them simultaneously. Based on implementation in wooden door industry, there are five attributes as the most impactful of SGA implementation identified by using Relief F method. The measurement of efficiency showed that Factory C 2014, Factory D 2014, Factory B 2015, and Factory C 2015 are the best decision making units. Strategies for increasing efficiency suggested by employee participation and innovation in SGA.

Keywords : Efficiency, Productivity, Small Group Activities (SGA)

ABSTRAK

LENA PUSPITA SARI.  Analisis Produktivitas di Industri Pintu Kayu Berdasarkan Small Group Activities. Dibimbing oleh TAUFIK DJATNA

Strategi untuk meningkatkan efisiensi dapat dibuat dengan mengusulkan partisipasi karyawan dan inovasi di SGA.

Kata Kunci: Efficiency, Productivity, Small Group Activities (SGA)
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PREFACE

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Author sincerely wishes that this work will give benefits to readers and contribute to the knowledge development. Correction and recommendation will gladly be accommodated.

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Lena Puspita Sari
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INTRODUCTION

Background

Productivity has an important role in a company, that have shown the ability to survive and thrive (Monhaty 1993). According Birgun et al. (2010), in the industrial engineering, productivity is defined as the ratio between outputs (products generated) with inputs (resources used). Some of the factors that affect the productivity of inputs, are: human, working capital, raw materials, utilities, other expenditures. Labor productivity is the use of human resources effectively and efficiently, accuracy or appropriateness of the use of methods or ways of working compared with the tools and time available, in order to achieve objectives (Siagian 1999). Human resources has the function of managing the input of the company to the maximum to obtain the results expected by the industry. The distinct character of human resources is firstly given by its uniqueness. It is the only resource that produces, creates and opens the perspective for continuous production innovation. Secondly, work resources have a limited qualitative-quantitative potential and the unlimited potential arises from the quality level (Juran and Gryna 1993).

One way to utilize effectively and efficiently of human resources is by the application of Small Group Activities (SGA) in improving the productivity of employees (Suryawati 2001). Small Group Activities (SGA) is identified as a major factor contributes to improve productivity. The creation of SGA occurs to improve activity in general and the capacity of the production in particular by an intensification of collaborator involvement. In SGA, employee were divided into a group consist 5-10 persons. This group created because they identify one or more problem together, try to solve their problems in their area and the end they report progress to the manager.

Problems often occur in the Small Group Activities is the lack of commitment to employees and management improvement (Putri 2014). Employee commitment is still lack in participating in these activities caused some employees may only focus on working and find it less necessary. Improvement management would also need to continue to facilitate and oversee implementation. But the lack attention of management can lead employees to be demotivate. Then, in the application of SGA, the industry has not fully known if SGA were applied in their industry is efficient or not.

Based on these conditions, this research is important to know what the most impactful factors that can increase employee commitment in SGA by Relief method. The efficiency measurement of each factory was analyzed by Data Envelopment Analysis (DEA). However, the observed values of the input and output data in real-world problems are sometimes imprecise or vague. Imprecise evaluations may be the result of unquantifiable, incomplete and non-obtainable information. Some researchers have proposed various fuzzy methods for dealing with the impreciseness and ambiguity in DEA. Based on it, this research will extend the CCR model to a fuzzy DEA model based on credibility measure and then give a fuzzy ranking method all DMUs with fuzzy inputs and outputs. Then,
strategies in improving SGA were as well built. So, it can be implemented by an industry to execute continuous development based on results of analysis.

This research focuses on the implementation of SGA provided by wooden door industry. There are previous works related to this study. Putri (2012) did a research using Relief method to measure what the variable of SGA that affected to employee productivity. Based on the sensitivity analysis, 65% response rate of respondents stated that the implementation of the SGA had been effective in improving employee productivity. This observation only measures the effectiveness of SGA implementation. Kazemi (2014) did a study by the feature of fully fuzzy DEA (FFDEA) is that it considers three situations for problem and solving them simultaneously. The first situation occurs in a desired condition with the highest output and lowest input. The second is made of centric point of inputs and outputs and which is analogous to the first condition. The third or undesired situation is when there are upper bound of input and lower bound of output. To collate the efficient units on the proposed method, this study used the obtained centric point for efficiency of units. Khaleghi et al. (2015) proposed a method to evaluate the performance of a set of DMUs and fully fuzzified environment. This method based on the multi-objective linear programming and the simplex method is proposed for computing an optimal fuzzy solution to a FFDEA problem in which fuzzy ranking function are not used.

The outline of this research is arranged as follows: research procedure and brief explanation about theories used are described in Method. Result and Discussion, describe the analysis and measurement of the efficiency for each DMUs of SGA. Several details about model are attached in Appendix section. The conclusion and recommendation for this research are explained in Conclusion and Recommendation.

Problem Definition

According to explanation in the previous section, note the important factors that can encourage the spirit of employees in the establishment of the SGA. A formulation in data mining technique helped to create a scoring system in figuring the most impactful factors in SGA. In sequent, its impact on the performance of the factory that produces the most efficient department helped in assessment of appropriate strategies.

Research Objectives

The objectives of this research are to solve the problems explained in the previous section, such as:
1) To observe the applicability of Small Group Activities (SGA) in the industry,
2) To identify the important factors that affect to establishments of Small Group Activities (SGA),
3) To measure efficiency of Small Group Activities implementation both using conventional and linguistic approaches, and
4) To evaluate and develop appropriate human resource strategy improvement.
Research Benefits

Strategies which built on this research gave benefit for the wooden door industry. From this research, the important factors which affect the implementation of SGA and efficiency level of SGA implementation were known. Another benefits were evaluation and development strategies of SGA. This research also improve author knowledge and experience about performance management and the advantages of using SGA implementations.

Boundaries of Research

This research is limited to observe the implementation of SGA, to identify the important factors in SGA, to gain information about efficiency and evaluation to support the implementation of SGA.

METHODOLOGY

This study divided into 4 major activities. Those 4 major aims to comply the research objective. Methods used in this study were literature study, observations/surveys, interview, questionnaire, Relief-F method, DEA and Fully Fuzzy DEA. The system framework shown in Figure 1. The system began with the identification and observation about SGA. Then analysis the questionnaire result using Relief F method were conducted in order to get the most impactful activities in SGA. After that, DEA and Fully Fuzzy DEA method were conducted to get the efficiency of each DMUs. Finally, the evaluation and strategy were arranged.

Identify the Small Group Activities (SGA) Attributes

Identification of SGA implementation was conducted to determine the parameters used in this research. SGA will be divided into three major groups, including support management, human resources, and the dynamics of the group. Based on three major group and interview with in the wooden door industry’s management, the involvement of employee was affected by 10 attributes. Then, those 10 attributes was broken down into 30 questions. Employee interview conducted by asking those 30 questions. This step aimed to determine the most impactful factor in SGA. The scale used in this questionnaire was Liker scale with an integer range from one to five. Beside interview, identification was done by studying related literature. The sampling method was judgment sampling which play role to employee characterization. By those method, the respondents were determined. Respondents in this study was SGA team member and coach who have potency to give improvement in their work area in this wooden door industry.
Identification and Selection of The Most Impactful Variables on Small Group Activities using Relief F

Identification and selection of variables that are most impactful to SGA were in Relief F method deployment. The aim of Relief to select features which are statistically relevance to the target concept (Kira and Rendell 1992). The equation of Relief F is represented as in (1). The main idea of Relief is to estimate attributes according to how well their values distinguish among the instances that are near to each other (Kononenko et al. 1996). In this study, Relief F method was used to figure out the most impactful factor of SGA system that industry have. In this study, Weka 3.7 is software as a tool of data processing.

$$W_f = \sum_{i=1}^{n-1} \frac{d_{iff}(x_i, y_j)^2}{(n-1)}$$

Figure 1 Research Flow Chart
The equation of Relief F is represented as in Formula (1) below. In the equation, firstly $i$th feature (the most impactfull variable in Small Group Activities) is defined, as $f_i$ where $F = \{ f_1, f_2, \ldots, f_n \}$, the weight of the $i$th feature as $w_i$ where $W = \{ w_{f1}, w_{f2}, \ldots, w_{fn} \}$, and the number of each feature data record for $n$ dimensional features ($i = 1, 2, \ldots, n$) and $n$ sample size ($t = 1, 2, \ldots, n$) which denotes as $x_{it}$ where $X = \{ x_{i1}, x_{i2}, \ldots, x_{im} \}$. Generally, the equation above uses a pairwise between data recorded ($x_t, y_j$) where $x_t$ indicates an instance of the feature data record and $y_j$ indicates an instance neighbor of $x_t$. In equation above, the function of $\text{diff} (x_t, y_j)^2$ is calculated as in Formula (3), where $r_{fi}$ is a range unit of $i$th feature attributes to normalize the values of the function into the interval $[0, 1]$. As stated in Formula (3), if pairwise between $x_t$ and $y_j$ are in the same class, then the value of function $\text{diff}$ is negative. Otherwise, function $\text{diff}$ will have a positive value when $x_t$ and $y_j$ are in a different class. In this research, Relief F method was ran to determine the top 5 rank attributes as the most impactful factors in Small Group Activities implementation.

Efficiency Level Analysis Using Data Envelopment Analysis (DEA)

In the case of evaluation the performance of factory operation was analyzed by using the data envelopment analysis (DEA). DEA is the mathematical programming for measuring and evaluating the relative efficiencies of production units termed the decision making units (DMUs), with the common inputs and outputs (Charnes et al. 1978). This research will extend the constant return to scale (CCR) model with output oriented. CCR model is a linear programming obtained as a ratio of the weighted output for the weighted input subject to the condition that the ratio for every entity is not larger than 1 (Wen et al. 2010). By considering the quotient of the total weight of outputs on total weight of inputs, the efficiency of this model can be calculated. Mathematically, it is described as follows:

$$\text{Max } E_p = \sum_{r} u_r y_{rp}$$

subject to $(s.t.)$

$$\sum_{i=1}^{m} v_{i} x_{ip} = 1$$

$$\sum_{r=1}^{s} u_r y_{rp} - \sum_{i=1}^{m} v_{i} x_{ip} \leq 0,$$

$$u_r v_{ri} \geq 0$$

$$\text{diff} (x_t, y_j)^2 = \left\{ \begin{array}{ll} \left( \frac{x_t - y_j}{r_{fi}} \right)^2 & \text{if } x_t, y_j \text{ are in the same class} \\ -\left( \frac{x_t - y_j}{r_{fi}} \right)^2 & \text{if } x_t, y_j \text{ are in a different class} \end{array} \right.$$
In equation (3), $E_p$ is the efficiency of DMUp. Consider, there are $n$ DMU in which $x_{ij}$ ($i = 1, 2, ..., m$) are inputs and $y_{rj}$ ($r = 1, 2, ..., s$) are outputs of DMUp ($p = 1, 2, ..., n$). Where $u_r$ ($r = 1, 2, ..., s$) and $v_i$ ($i = 1, 2, ..., m$) are the weights assigned to the $r_{th}$ output and $i_{th}$ input, respectively. CCR model has the assumption that the ratio of the addition of the input and output is the same (constant return to scale). This means if there are additional input and output by $x$ number, then the output will increase by $x$ number as well. Output oriented means the number of outputs can be increased proportionally without changing the number of inputs (Rusydiana et al. 2013). In an output-oriented model, an inefficient unit is made efficient through the proportional increase of its outputs, while the inputs proportions remain unchanged. In this research, MaxDEA Pro 6.3 (Gang and Zhenhua 2014) software used as a tool of data processing to get the score of efficiency of each DMUs.

**Efficiency Level Analysis Using Fully Fuzzy DEA Model**

The DEA results group the DMUs into two sets: one set is efficient DMUs and the other is inefficient DMUs. In many cases, it is necessary to give a full ranking of the DMUs. For this purpose, different methods with different properties to achieve full ranking of DMUs have been proposed. In this study, an FFDEA problem is discussed, and a method for solving this FFDEA problem is also proposed. The acquired fuzzy efficiency scores with solving FFDEA. Afterwards, this study used a ranking function to rank these fuzzy scores (Khaleghi 2015). All previously defined parameters would be fuzzified ($\tilde{\cdot}$). This equation (4) is formed when all the inputs, outputs, and decision variables on the DEA are defined as the triangular fuzzy numbers (TFN) (Kazemi and Alimi 2014).

$$
\text{Max } E_p = \sum_{r=1}^{s} \tilde{u}_r \otimes \tilde{y}_{rp}
$$

As seen from equation (4), all the decision variables and model parameters are fuzzy and their relations are fuzzy too. The components of equation ($\sim$) are defined according to equation (5).

$$
\begin{align*}
\tilde{u}_r &= (u_r, s_r, t_r) \\
\tilde{y}_{rp} &= (y_{rp}, b_{rp}, z_{rp}) \\
\tilde{v}_i &= (v_i, l_i, d_i) \\
\tilde{x}_{ip} &= (x_{ip}, a_{ip}, c_{ip})
\end{align*}
$$

In the equation 4 all the numbers are defined as triangular fuzzy, that by putting these components on equation (5), it will reach to equation (6). In equation
(6) the first constraint is less or equal due to increase of solutions space and avoiding non feasible answers (Kazemi et al. 2014)

\[
\text{Max } E_p = \sum_{r=1}^{s} (u_r, s_r, t_r) \otimes (y_{rp}, b_{rp}, z_{rp})
\]

s.t.
\[
\sum_{i=1}^{m} (v_i, l_i, d_i) \otimes (x_{ip}, a_{ip}, c_{ip}) \leq (1,1,1)
\]
\[
\sum_{i=1}^{m} (u_r, s_r, t_r) \otimes (y_{rp}, b_{rp}, z_{rp}) - \sum_{i=1}^{m} (v_i, l_i, d_i) \otimes (x_{ip}, a_{ip}, c_{ip}) \leq (0,0,0)
\]
\[
(v_i, l_i, d_i), (x_{ip}, a_{ip}, c_{ip}) \geq 0
\]

For the purpose to solve fully fuzzy models, this study follows the approach of Kumar et al. Kumar et al (2014) wrote ranking function for objective function and change every constraint into 3 constraints: constraint for upper bound, centric point and lower bound. This equation (6) is the proposed model of this study follow the approach of Khaleghi (2015) that apply the fully fuzzy linear programming model namely level-sum method and transform the fuzzy DEA model to the following equation (7). This equation is used when the data of a problem (inputs and outputs) are triangular fuzzy. By solving model of Fully Fuzzy DEA on Lingo 16.0 software, the efficiency of DMUs is calculated. \( u_1 \) and \( u_2 \) are lower bound of outputs. \( s_1 \) and \( s_2 \) are centric point of outputs. \( t_1 \) and \( t_2 \) are upper bound of outputs. \( v_1 \) and \( v_2 \) are lower bound of inputs. \( l_1 \) and \( l_2 \) are centric point of inputs. \( d_1 \) and \( d_2 \) upper bound of inputs.

\[
\text{Max } E_p = \sum_{r=1}^{s} (u_r, y_{rp}, b_{rp}, t_r) z_{rp})
\]

s.t.
\[
\sum_{i=1}^{m} v_i x_{ip} \leq 1,
\]
\[
\sum_{i=1}^{m} l_i a_{ip} \leq 1,
\]
\[
\sum_{i=1}^{m} d_i c_{ip} \leq 1,
\]
\[
\sum_{r=1}^{s} u_r y_{ri} - \sum_{i=1}^{m} d_i c_{ij} \leq 0,
\]
\[
\sum_{r=1}^{s} b_{ri} - \sum_{i=1}^{m} l_i a_{ij} \leq 0,
\]
\[
\sum_{r=1}^{s} t_r z_{ri} - \sum_{i=1}^{m} v_i x_{ij} \leq 0,
\]
In order to rank the DMUs efficiency, we use ranking function. A simple method for ordering fuzzy numbers consists in the definition of a ranking function \( F \), mapping each fuzzy number to the real number \( R \), where a natural order exists. Here we introduce a linear ranking function that is similar to the ranking function.

For any arbitrary fuzzy number \( \tilde{A} = (\tilde{A}(r), \tilde{A}(r)) \), we use ranking function as follows:

\[
D(\tilde{A}) = \frac{1}{2} \int_{0}^{1} A(r) \, dr + \frac{1}{2} \int_{0}^{1} \tilde{A}(r) \, dr
\]

For transformation into a triangular fuzzy number this reduces into:

\[
D(\tilde{A}) = a^{(2)} + \frac{1}{4}(a^{(3)} - a^{(1)}) \quad (\text{Khalegi et al. 2015}).
\]

**Evaluation and Strategy Improvement**

Priorities were divided from Relief F method in order to consider most influential parameters to handle and to keep. Then, the calculation of DEA method will generate the efficiency values for each factory. The results of Relief and DEA method provide the basis for designing evaluation and strategy. Based on the level of efficiency of each factory considered the steps which taken towards the important factors that support the SGA implementation.

**RESULT AND DISCUSSION**

**Result**

**The Analysis of Small Group Activities System in Wooden Door Industry**

Small Group Activities (SGA) is a small group of employees who formed voluntary identification of problems and improvements in the quality of work, products or working conditions sustainable. SGA consists of five people from the same unit of work together and volunteer activities in the field of repair and improvement of the work itself and the results are to be applied within the scope of their work. Some of the terms used in the SGA, namely:

1. Coach is a term for foreman in every factory involved in the formation of the SGA group to guide, advise, and oversee the development of the SGA team. The coach is also the liaison between the SGA team and the management in reporting the results of his team improvement.
2. SGA team leader is a person who leads the SGA group and selected by each member of the team when it was formed. A team leader must have enthusiasm, instrumental in motivating the group, lead in all discussions, to mediate in any differences of opinion, and maintain the cohesiveness of the team.
3. SGA team members are the people who are involved in the implementation of the SGA.
4. Mechanics are people who may or may not be involved in the SGA group. Said to be involved if the repairs do require mechanical assistance, especially if it relates to machine tools and etc.

SGA in the wooden door industry was called as Kaizen 555. This means, 5 employee in 5 days should be implemented 5 innovations. On the last day, in Friday, they presented their innovation in front of management. This day was called lean Kaizen celebration. The employee knows well about their area, so they are know exactly what the problem is and they can find the best solution about it.

By implementing this system, in this figure (2), there is a significant improvement. In 2015 the implementation were a bit decrease, this happened because the wooden door industry must fulfill excess demand. So they side SGA for a while.

![Figure 2 Total of Improvement since 2012-2015]

Since the implementation of the Small Group Activities (SGA) obtained data on the number of improvements starting in 2012 (31 improvements), 2013 (55 improvements), 2014 (152 improvements) and 2015 (125 improvements). Improvements were insignificant but certainly had a considerable impact on the comfort, safety, and ease of doing all the activities of workers in their work area. This is certainly impacted the wooden door industry by increasing worker productivity because employees have been doing all the activities in the process of the work area with comfortable and safe. Every department in the wooden door industry is free to participate in the SGA. However, since the application who more contributed is production employees.

In order to identify the most impactful variables on SGA in the wooden door industry, the influential variables were specified. Then, interviews and literature studies were brought as well. The result based on three major group was ten attributes that influenced SGA in the wooden door industry. These attributes are management involvement, purpose of SGA, motivation of SGA, activeness of employee, compactness, leadership of chairman SGA, quality control techniques, availability of facilities, reward, and position/field work. Entire ten attributes afterwards were decomposed into 30 variables which then set as questions on the questionnaire. Thirty variables obtained by consulting with management adjusted to the application in the industry SGA. Determination of these thirty variables is
also based on all aspects of supporting the continued application of the SGA. The questionnaire was necessary to determine SGA with each attribute and used as tool in conducting interviews with management and employees. Form of the questionnaire can be seen in Appendix 1. The result of the questionnaire can be seen in Appendix 2. The result of the questionnaire was then applied as data in following Relief and DEA analysis.

Table 1 Attribute and activity of SGA in the wooden door industry

<table>
<thead>
<tr>
<th>Number</th>
<th>Attribute</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Management Involvement</td>
<td>Management Support</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Contribution Management</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Monitoring And Evaluation</td>
</tr>
<tr>
<td>4</td>
<td>Purpose of SGA</td>
<td>Innovation</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Problem Solving</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Improving Ability</td>
</tr>
<tr>
<td>7</td>
<td>Motivation of SGA</td>
<td>Want Appreciated</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Easiness</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Productivity</td>
</tr>
<tr>
<td>10</td>
<td>Activeness of Employees</td>
<td>Feel Free to Say What They Think</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Responsibility</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Participation</td>
</tr>
<tr>
<td>13</td>
<td>Compactness</td>
<td>Team Work</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Believe Each Other</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Discussion</td>
</tr>
<tr>
<td>16</td>
<td>Leadership of Chairman SGA</td>
<td>Leadership</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Coordination</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Provide Opportunity</td>
</tr>
<tr>
<td>19</td>
<td>Quality Control Techniques</td>
<td>Implementation 7 Waste</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>Implementing 5S</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Gemba</td>
</tr>
<tr>
<td>22</td>
<td>Availability of Facilities</td>
<td>Improvement Facility</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Facilitator</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Coach</td>
</tr>
<tr>
<td>25</td>
<td>Reward</td>
<td>Improvement</td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Active Role</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Implementation</td>
</tr>
<tr>
<td>28</td>
<td>Position/Field Work</td>
<td>Special Job</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>Special Competence</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>Frequency</td>
</tr>
</tbody>
</table>
Variables are explained in detail to the operational definition as follows:

1. Management Involvement: an assessment of the role in supporting, contributing as well as monitoring and evaluation in the management of SGA implementations.
2. Purpose of SGA: an assessment of the role in supporting, contributing with monitoring and evaluation in the management of SGA activities.
3. Motivation of SGA: things that encourage employees because they want to get appreciation, ease the work, and increase work productivity.
4. Activeness of Employees: SGA is able to make employees more freedom in conveying what they were thinking, responsibly, and participate in improving the comfort in the work.
5. Compactness: include teamwork, trust each other, and a good discussion in solving the problems that exist in the work area.
6. Leadership of Chairman SGA: the liveliness of a chairman SGA group in terms of leadership, coordinating his teammates in every discussion and presentation and to provide an opportunity for each of the members of his team feel comfortable in delivering his opinion.
7. Quality Control Techniques: include procedures for employees to identify problems that exist in the work area such as the application of seven waste, 5S, and Gemba.
8. Availability of Facilities: includes the improvement of facilities to support the performance of SGA in industries such as support facilities, facilitator and coach for each group of SGA.
9. Reward: existence reward cause employees are more motivated to improve the improvement in work area and an active role in implementing any innovation that has been implemented.
10. Position/Field Work: special working fields, special abilities, and related frequency in the work area can affect the formation of the SGA team in creating improvement.

The most impactful variables on Small Group Activities using Relief F

The results of Relief calculation show the weight value of each service attribute. Kira and Rendell (1992) describe that the threshold weight value must be determined. The purpose of threshold value determination was to determine which features have an influence to SGA. Attributes that are impactful in SGA implementation are ordered beginning with the largest value.

The attributes are ability increase \((x_6)\), problem solving \((x_5)\), frequency \((x_{30})\), special competence \((x_{29})\) and innovation\((x_4)\). This indicates from forty respondents. Respondents selected are forty employees who are active in SGA and based on recommendation from management. Thirty five people composed of production employees and five others are the coach of several teams. The result of important factors is used as information for authors, readers and industry, particularly in knowing what is the biggest factor in supporting the establishment of SGA. Based on these attributes were also to build the strategies in order to improve manageability. The result of important factors is used as information for
Efficiency Model of Small Group Activities Implementation using Data Envelopment Analysis (DEA)

DEA method used to calculate the level of efficiency of every factory in the wooden door industry. The first step for efficiency measurement are determined DMU, input and output for constructing linear programming of each DMU. Then calculate the relative efficiency for each DMU. DMU is defined as an object to be assessed efficiency. This study is used as DMU are factory A, B, C, and D in the wooden door industry. All of the factory are the parts involved in the process of producing doors in the wooden door industry. DEA methods necessary in using the same input and output for each DMU assessed. This study used two inputs and
two outputs. Input used is the total employees and total coach. Output is the total improvement and the number of people who contribute. Input and output factors have been based on what is needed in the formation of the SGA and what is produced. In addition, it is also determined based on discussions with management. Calculation of efficiency is important to know the level of contribution of each factory in the wooden door industry. The advantages of this method is the DEA can generate relative efficiency for each DMU assessed and get strategies that can be used for improvement if the DMU is not efficient. Table 3 provides the information of DMUs data that will be used to calculated efficiency of the DEA method.

Equation (9) is a model linear programming to calculate the Factory A 2014’s efficiency and 7 other equations have to be written to be written to calculate the efficiency of other units (Appendix 3). The complete linear programming model for the Factory A 2014’s efficiency has four variables and nine constraints.

\[
\text{Max } E_1 = 65y_1 + 79y_2
\]

s.t

\[
\begin{align*}
212x_1 + 10x_2 & = 1, \\
65y_1 + 79y_2 - 212x_1 - 10x_2 & \leq 0 \\
41y_1 + 10y_2 - 121x_1 - 5x_2 & \leq 0 \\
11y_1 + 10y_2 - 13x_1 - 3x_2 & \leq 0 \\
35y_1 + 35y_2 - 77x_1 - 2x_2 & \leq 0 \\
39y_1 + 40y_2 - 212x_1 - 10x_2 & \leq 0 \\
59y_1 + 57y_2 - 121x_1 - 5x_2 & \leq 0 \\
10y_1 + 10y_2 - 13x_1 - 3x_2 & \leq 0 \\
8y_1 + 10y_2 - 77x_1 - 2x_2 & \leq 0 \\
\end{align*}
\]

In equation (9), \( E_1 \) is the efficiency of DMU1. Consider, there are 8 DMU in which \( x_1 \) and \( x_2 \) are inputs and \( y_1 \) and \( y_2 \) are outputs of DMU. The result from DEA method can be seen in the Table 4. Based on the requirement of DEA method, if DMUs have scores of less than 1 but greater than 0 and thus they are identified as inefficient. Its can figure out which factory in which year who already have the perfect efficiency score of 1. They are factory B 2015, factory C 2014 - 2015 and factory D 2015. In the other hand we still found 4 other factory’s who still didn’t reach the score of 1. They are factory A 2014-2015, factory B 2014, and factory D 2015. Based on the requirement of the wooden door industry, data used 2014 and 2015 (the most recent ones).

**Efficiency Model of Small Group Activities Implementation using Fully Fuzzy DEA**

Motivation in calculating the efficiency of fuzzy DEA method originated from difference opinion on the management by the results that have been obtained of DEA method. Some people are agree with these results, but some other may have other opinions in order to achieve efficiency. The difference of opinion is then carried back to the calculation method of fully fuzzy DEA to equalize the different opinions. Table 3 provides the information of the DMUs. There are two...
fuzzy inputs and two fuzzy outputs which are all triangular variables. The feature of this proposed model is that it considers 3 situations for problem solving simultaneously. The first situation is the minimum condition that can be tolerated by the wooden door industry. The second is the ideal condition that occur in the industry. The third situation is the situation in which the input is the maximum condition and the output is the result obtained from 2014 - 2015. Figure (3) shows case in which the wooden door industry, at the lowest point in the left shows the minimum conditions that can be tolerated and right end point indicates the maximum point. The highest point shows acceptable ideal condition.

Figure 3 A triangular fuzzy number of the total employees in Factory A 2014

<table>
<thead>
<tr>
<th>DMU</th>
<th>Input 1</th>
<th>Input 2</th>
<th>Output 1</th>
<th>Output 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory A 2014</td>
<td>(200, 205, 212)</td>
<td>(8, 9, 10)</td>
<td>(55, 60, 65)</td>
<td>(35, 50, 79)</td>
</tr>
<tr>
<td>Factory B 2014</td>
<td>(110, 115, 121)</td>
<td>(3, 4, 5)</td>
<td>(31, 36, 41)</td>
<td>(5, 7, 10)</td>
</tr>
<tr>
<td>Factory C 2014</td>
<td>(10, 12, 13)</td>
<td>(2, 2, 3)</td>
<td>(5, 8, 11)</td>
<td>(5, 7, 10)</td>
</tr>
<tr>
<td>Factory D 2014</td>
<td>(70, 75, 77)</td>
<td>(2, 2, 2)</td>
<td>(25, 30, 35)</td>
<td>(15, 25, 35)</td>
</tr>
<tr>
<td>Factory A 2015</td>
<td>(200, 205, 212)</td>
<td>(8, 9, 10)</td>
<td>(29, 39, 212)</td>
<td>(20, 30, 40)</td>
</tr>
<tr>
<td>Factory B 2015</td>
<td>(110, 115, 121)</td>
<td>(3, 4, 5)</td>
<td>(49, 59, 121)</td>
<td>(25, 45, 57)</td>
</tr>
<tr>
<td>Factory C 2015</td>
<td>(10, 12, 13)</td>
<td>(2, 2, 3)</td>
<td>(5, 10, 13)</td>
<td>(5, 7, 10)</td>
</tr>
<tr>
<td>Factory D 2015</td>
<td>(70, 75, 77)</td>
<td>(2, 2, 2)</td>
<td>(5, 8, 77)</td>
<td>(5, 7, 10)</td>
</tr>
</tbody>
</table>

Equation (10) is created by putting the data of Table 3. This equation is written to calculate the first decision making units efficiency and 7 other equations have to be written to calculate the efficiency of other units (Appendix 4).

\[
\text{Max } \bar{E}_1 = 55u_1 + 35u_2 + 60s_1 + 50s_2 + 65t_1 + 79t_2
\]

\[
s.t. \\
200v_1 + 8v_2 \leq 1, \\
205l_1 + 9l_2 \leq 1, \\
212d_1 + 10d_2 \leq 1, \\
55u_1 + 35u_2 - 212d_1 - 10d_2 \leq 0, \\
\vdots \\
60s_1 + 50s_2 - 205l_1 - 9l_2 \leq 0,
\]
In equation (10), \( \hat{E}_1 \) is the efficiency of DMU\(_1\). In equation (7), there are 15 constraints totally that just wrote some of them. In the proposed model, there is \( 3n + 3 \) constraints and \( n \) is the number of DMUs. By solving equation (10) on Lingo 16.0 software, the efficiency of DMUs is calculated and its result is on Table 4.

<table>
<thead>
<tr>
<th>DMU</th>
<th>DEA</th>
<th>Fully Fuzzy DEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory A 2014</td>
<td>0.765</td>
<td>(0.1925, 0.2750, 0.4345)</td>
</tr>
<tr>
<td>Factory B 2014</td>
<td>0.700</td>
<td>(0.2325, 0.2700, 0.3075)</td>
</tr>
<tr>
<td>Factory C 2014</td>
<td>1</td>
<td>(0.3875, 0.5383, 0.7690)</td>
</tr>
<tr>
<td>Factory D 2014</td>
<td>1</td>
<td>(0.2355, 0.3925, 0.5495)</td>
</tr>
<tr>
<td>Factory A 2015</td>
<td>0.393</td>
<td>(0.1100, 0.1650, 0.2200)</td>
</tr>
<tr>
<td>Factory B 2015</td>
<td>1</td>
<td>(0.4018, 0.4510, 0.4838)</td>
</tr>
<tr>
<td>Factory C 2015</td>
<td>1</td>
<td>(0.3845, 0.6152, 0.7690)</td>
</tr>
<tr>
<td>Factory D 2015</td>
<td>0.436</td>
<td>(0.0785, 0.1099, 0.1570)</td>
</tr>
</tbody>
</table>

Table 5 Ranking of fuzzy efficiency scores

<table>
<thead>
<tr>
<th>DMU</th>
<th>DEA</th>
<th>Rank</th>
<th>FFDEA</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory A 2014</td>
<td>0.765</td>
<td>2</td>
<td>0.3355</td>
<td>5</td>
</tr>
<tr>
<td>Factory B 2014</td>
<td>0.700</td>
<td>3</td>
<td>0.2887</td>
<td>6</td>
</tr>
<tr>
<td>Factory C 2014</td>
<td>1</td>
<td>1</td>
<td>0.6344</td>
<td>2</td>
</tr>
<tr>
<td>Factory D 2014</td>
<td>1</td>
<td>1</td>
<td>0.4710</td>
<td>4</td>
</tr>
<tr>
<td>Factory A 2015</td>
<td>0.393</td>
<td>5</td>
<td>0.1925</td>
<td>7</td>
</tr>
<tr>
<td>Factory B 2015</td>
<td>1</td>
<td>1</td>
<td>0.4715</td>
<td>3</td>
</tr>
<tr>
<td>Factory C 2015</td>
<td>1</td>
<td>1</td>
<td>0.7113</td>
<td>1</td>
</tr>
<tr>
<td>Factory D 2015</td>
<td>0.436</td>
<td>4</td>
<td>0.1295</td>
<td>8</td>
</tr>
</tbody>
</table>

On DEA models, the efficient units are compared with these efficient units. In 2014, factory C and D have been efficient, but in 2015 only factory B and C are efficient. Based on Table 4, the efficiency of every decision making unit is a triangular fuzzy number that its upper bound is 1 or a number near 1. Therefore, the proposed model of this study is designed as a desired situation that can be
obtain by using lower bound of inputs and upper bound of outputs and also maximum efficiency of every unit can be determine that this number is the highest efficiency on Table 4. By considering lower bound of output and upper bound of input, that can achieve the lower bound of efficiency. This is the worst situation for efficiency of a unit and shows that the efficiency of this unit won’t get lower than this number. By solving the problem in equation (10), $\tilde{u}_1 = (0,0,0), \tilde{u}_2 = (0.0055, 0.0055, 0.0055)$ and $E_1 \approx (0.1925, 0.2750, 0.4345)$ is an optimal fuzzy solution to the given initial fully fuzzy DEA problem. In all of methods, Factory C and D 2014, Factory B and C 2015 have the highest efficiency. This study applied fuzzy ranking function to the result FFDEA method, the result are presented in Table 5. Based on Table 5, this study will notice that Factory C 2014, Factory D 2014, Factory B 2015, and Factory C 2015 will be classified in first rank and Factory A 2014 in second rank. Also the Factory B 2014, Factory D 2015, and Factory A 2015 are located in third, fourth, and fifth ranks, respectively. But generally, as for Table 4 and 5 all methods are assessed Factory C 2014, Factory D 2014, Factory B 2015, and Factory C 2015 best decision making units.

**Evaluation and Strategy Improvement**

As seen at the results of the calculation of the efficiency, not all existing factory in the wooden door industry has been efficient in applying the SGA. It shows that not all employees are actively involved in following the SGA. So, in order to achieve an efficient value for each factory in relations with the employee owned by the factory is by increasing the improvement level in work area as well as active involvement of all employees. In this way, it is recognized that employees becomes more responsible, more careful and more involved in work when they feel appreciated thus increasing work productivity.

Based on above results, the best strategies to improve efficiency was to give priority to the five top ranks of SGA to achieve the previous targets measured by the DEA. As previously mentioned, these strategies included constructed SGA were ability increase, problem solving, frequency, special competence and innovation. In order to achieve the whole integration, conditions below which must be followed:

1. In case of efficient factory, it is necessary to maintain the five top ranks of SGA that has been obtained by the Relief F method.
2. In case of inefficient factory, it is necessary to increase the five top ranks of SGA that has been obtained by the Relief F method.

**Discussion**

A Small Group Activities (SGA) is volunteer group composed of members who meet to talk about workplace and service improvements and make presentations to their management with their ideas. SGA is nothing but a small group of employees who come together to discuss with the management issues related to either quality control or improvement in production methods form a Quality Control Circle (QCC). Those members are related especially to the quality of output or services in order to improve the performance of the
organization/department and motivate and enrich the work of employees. In other words, they usually work in the same areas, and voluntarily meet on a regular basis to identify, analyze and solve their problems. So that with the equality of employees that will affect the advancement of the industry. From this study also can be known what the reason employee contributes in SGA. It is employees feel with the implementation of the SGA can increase the ability of employees and can solve problems that exist in the work area. Implementation of SGA in the wooden door industry had an impact on the productivity performance of each factory.

Data Envelopment Analysis (DEA) and Fully Fuzzy DEA in this study help to measure the efficiency of each Factory. The calculation of efficiency is important to know the level of contribution of each factory in the wooden door industry. Increased number of employee involved and more innovations in improvements can increase productivity in the wooden door industry. The way to increase the involvement is to foster a sense of belonging to the company and also consider the top five factors that can increase the sense involvement from employees in SGA.

Advantages and Disadvantages

The implementation of Relief F and DEA to develop Human Resources Management (HRM) strategy was highly potential. The management, especially HRM, owned knowledge of the most impactful variables on SGA. Then, efficiency model of SGA was beneficial to determine the efficiency of each factory in the wooden door industry. Afterwards, development of strategies for SGA was required. The Fully Fuzzy DEA in this study is helping to solve the uncertainty in human thinking and judgement. In this study by using this idea, the DEA model on a fully fuzzy mode is proposed. The feature of this proposed model is that it considers three situations for problem and solving. So based on it, the advantage of this model is that it can choose a desired situation for decision making units and compare its situation with desired situation. With using of this method, this study obtain fuzzy efficiency scores and DMUs are ranked. The disadvantage of this study, measurement was only applied on the operational level of the wooden door industry and this study only using a DEA method with CCR model and output oriented.

CONCLUSION AND RECOMMENDATION

Conclusion

The main idea of SGA is these groups voluntarily carry out workplace improvement tasks within a large company program for quality control, production increase, education and self development. Based on Relief F method, there are top five attributes affect in SGA implementation. Generally, Factory C 2014, Factory D 2014, Factory B 2015, and Factory C 2015 are the best decision making units. The best strategy was to fulfill projection as the target for each department and increase SGA by improving the top five rank.
Recommendation

Based on several disadvantages explained, the author recommends to include management level in SGA processes and a consistent time based measurement should be applied for the whole respondents sampling. It is also recommended that the method used in this study can be used on input-oriented and variable return to scale (BCC) models and its results can be compared.

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Rusydiana et al. 2013. Mengukur Tingkat Efisiensi dengan Data Envelopment Analysis (DEA): Teori dan Aplikasi


| **C** | Constant return to scale (CCR) | A linear programming obtained as a ratio of the weighted output for the weighted input subject to the condition that the ratio for every entity is not larger than 1. | Wen *et al.* 2010 |
| **D** | Data Envelopment Analysis (DEA) | The mathematical programming for measuring and evaluating the relative efficiencies of production units termed the decision making units (DMUs), with the common inputs and outputs | Charnes *et al.* 1978 |
| **E** | Decision Making Units (DMU) | A unit that became the basis of measurement of the decision making performance value | Ramanathan 2003 |
| **F** | Efficiency | Generally refers to using the minimum number of inputs for a given number of outputs. | Ozcan YA 2014 |
| **G** | Fully Fuzzy DEA (FDEA) | The model enables analysts to assimilate the imprecise and vague data in formal systematic approach | Hatami *et al.* 2011 |
| **H** | Fully Fuzzy Linear Programming (FFLP) | The FLP problems in which all the parameters as well as the variables are represented by fuzzy numbers | Shamooshaki *et al.* 2014 |
| **I** | Gemba | A philosophy that reminds us to get out offices and spend time on the plant floor the place where the real action occurs | Bhasin S 2015 |
| **J** | Human resources | The only production factor capable of creating new values, the creator and a stimulator of production means | Blaga P and Jozsef B 2014 |
| **K** | Input Oriented | If the number of inputs can be reduced proportionately without changing the number of outputs used | Rusydiana *et al.* 2013 |
| **L** | Kaizen | A strategy where employee work together proactively to achieve regular, incremental improvements | Bhasin S 2015 |
in the manufacturing process

**L**: Linear Programming

The process of taking various linear inequalities relating to some situation, and finding the "best" value obtained under those conditions. 

Shamooshaki *et al.* 2014

**M**: Membership function

A curve that shows the mapping points of input data into membership values (often called the degree of membership) which has the interval between 0 and 1.

Kusumadewi S and Purnomo H. 2004

**O**: Output Oriented

If the number of outputs can be increased proportionately without changing the number of inputs used.

Rusydiana *et al.* 2013

**P**: Productivity

The ratio between outputs (products generated) with inputs (resources used).

Birgun *et al.* 2010

**S**: Small Group Activities (SGA)

A small group of employees who formed voluntary identification of problems and improvements in the quality of work, products or working conditions sustainable.

Blaga P and Jozsef B 2014

**T**: Triangular fuzzy

That used to quantify the vagueness in the decision parameters and the input and output data in the above model.

Wang and Elhag 2006

**V**: Variable Return to Scale (BCC)

This model assumes the addition of x times the input will not cause output increased by x times, can be smaller or larger than x times.

Rusydiana *et al.* 2013
Appendix 1. Questionnaire of the impactful activity in Small Group Activities

KUESIONER

Analisis Produktivitas di Industri Pintu Kayu Berdasarkan Penerapan Small Group Activities

Hasil pengisian kuesioner ini akan digunakan untuk keperluan penelitian dari penyusunan skripsi dengan judul “ANALISIS FAktOR PRODUKTIVITAS PADA PENERAPAN SMALL GROUP ACTIVITIES DI PT L”. Penelitian ini dilaksanakan oleh Lena Puspita Sari/F34120147, Mahasiswa Departemen Teknologi Industri Pertanian, Fakultas Pertanian, Institut Pertanian Bogor.

Bogor, Maret 2016
PETUNJUK UMUM

Bapak/ibu responden Yth,

Kami memahami bahwa waktu Anda sangat terbatas dan berharga, walaupun demikian Anda dimohon bersedia untuk membantu penelitian ini dengan mengisi kuesioner yang diberikan. Tujuan penelitian ini adalah mengamati penerapan Small Group Activities (SGA) di PT L, mengidentifikasi faktor-faktor penting yang berpengaruh terhadap pembentukan SGA, mengukur tingkat efisiensi dan efektifitas dalam pengaruhnya terhadap produktivitas, serta sebagai evaluasi dan pengembangan dalam meningkatkan kualitas perusahaan dalam jangka panjang.

Hasil penelitian akan memberikan masukan bagi pihak manajemen untuk mengetahui efisiensi dan efektivitas SGA terhadap produktivitas kerja karyawan. Penilaian terhadap produktivitas kerja karyawan melalui kuesioner ini mempunyai tingkat objektivitas tinggi dan adil bagi seluruh karyawan. Untuk penelitian ini, Anda dimohon mengisi kuesioner yang terdiri dari dua bagian yaitu :

Bagian I : Identitas responden
Bagian II : Faktor yang berpengaruh terhadap penerapan SGA

Untuk dapat menjawab kuesioner ini dengan lengkap, Anda diminta untuk mengikuti langkah-langkah di bawah ini:
1. Lihatlah secara sepintas seluruh kuesioner. Anda mendapatkan kuesioner yang terdiri dari 2 (dua) halaman.
3. Apabila ada pertanyaan yang tidak terjawab, maka akan menyebabkan seluruh jawaban anda tidak dapat diolah.
5. Pastikan anda telah menjawab semua pertanyaan dalam kuesioner ini.

Terimakasih atas kesedian Bapak/Ibu mengisi kuesioner ini.
ANALISIS FAKTOR PRODUKTIVITAS DENGAN PENERAPAN SMALL GROUP ACTIVITIES DI PT L

Bagian I

Jawablah pertanyaan-pertanyaan di bawah ini sesuai petunjuk dengan memberi tanda check list (✓) pada jawaban yang sesuai dan mengisinya dengan benar dengan pilihan Sangat Tidak Setuju (1), Tidak Setuju (2), Cukup Setuju (3), Setuju (4), dan Sangat Setuju (5).

1. Nama : .................................................................
2. Jenis kelamin : □ Laki-laki □ Perempuan
3. Umur : ........................................... tahun
4. Status menikah : □ Menikah □ Belum
5. Pendidikan : □ SD □ SMP □ SMA □ Perguruan Tinggi
6. Masa kerja : ........................................... tahun
7. Bidang pekerjaan : .................................................................
8. Nama grup SGA : .................................................................

Bagian II

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<td>Pihak manajemen mendukung berlangsungnya proses Kaizen 555</td>
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<td>Atasan Anda (lingkungan manajemen) aktif melancarkan kegiatan Kaizen 555</td>
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<td>Pihak manajemen aktif menyelenggarakan kegiatan Kaizen 555</td>
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<td>Dengan adanya Kaizen 555, saya dapat berinovasi di tempat kerja</td>
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<td>Selama ini, Kaizen 555 telah menyumbangkan pemecahan masalah dan pengembangan bagi perusahaan</td>
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<td>Kaizen 555 mampu meningkatkan kemampuan karyawan</td>
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<td>Dengan berikut dihargai Kaizen 555, keberadaan saya sebagai pekerja</td>
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<td>Dengan adanya Kaizen 555 akan memudahkan pekerjaan saya</td>
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<td>Produktivitas kerja saya akan meningkat dengan adanya Kaizen 555</td>
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<td>Dalam menyampaikan gagasan, saya bebas berbicara dan saling bertukar pikiran dengan rekan satu grup maupun atasan</td>
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<td>Setiap kelompok memiliki tanggung jawab dalam menyelesaikan masalah yang ada di lingkungan kerjanya</td>
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12. Setiap karyawan turut berperan aktif dalam berpartisipasi dalam kelompok Kaizen 555
13. Kerjasama dalam menyelesaikan masalah terjalin dengan baik antara sesama anggota Kaizen 555
14. Kelompok Kaizen 555 saya saling percaya satu sama lain
15. Kelompok Kaizen 555 saya sering berdiskusi dalam pemecahan masalah dilingkungan kerja
16. Ketua Kaizen 555 saya memimpin dengan baik dan menanamkan tanggung jawab kepada setiap anggota SGA dalam menyelesaikan tugas
17. Ketua Kaizen 555 saya mampu mengkoordinasikan anggota kelompok Kaizen 555 dan menyampaikan materi dengan baik
18. Ketua Kaizen 555 saya selalu memberikan kesempatan kepada saya dalam mengembangkan ide dan kreatifitas di lingkungan kerja
19. Dengan membudayakan 7 waste, produk cacat dalam kegiatan produksi telah menurun
20. Dengan menjalankan 5S di lingkungan kerja, saya lebih merasa nyaman dalam bekerja
21. Setelah melakukan gemba di lokasi kerja, inovasi yang saya buat saya terapkan dengan baik
22. Fasilitas (ruang, waktu, pertemuan khusus, alat-alat) yang disediakan oleh perusahaan untuk kegiatan Kaizen 555 berada dalam kondisi baik
23. Fasilitator saya bersungguh-sungguh dalam menyediakan fasilitas yang diperlukan oleh Kaizen 555
24. Coach memfasilitasi dan memberikan masukan ketika tim Kaizen 555 memiliki kendala dalam penyelesaian masalah
25. Dengan adanya bingkisan/hadiah atas improvement yang dibuat membuat semakin banyak improvement yang dihasilkan
26. Hadiah dari manajemen atas prestasi Kaizen 555 dapat meningkatkan kinerja karyawan dalam berperan aktif pada Kaizen 555
27. Saya bangga ketika hasil improvement saya dihargai dan diterapkan di tempat kerja
28. Dengan bidang kerja saya saat ini akan lebih memudahkan saya dalam menyelesaikan masalah Kaizen 555
29. Bidang kerja yang saya tangani akan mempengaruhi perbaikan yang saya lakukan di tempat kerja
30. Semakin sering saya menangani suatu bidang pekerjaan tertentu akan memudahkan saya melakukan perbaikan di tempat tersebut

--- TERIMA KASIH ---
## Appendix 2. Result of questionnaire from 40 respondents

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<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix 3. Model Data Envelopment Analysis

a. Model DEA to calculate the Factory B 2014’s efficiency

\[ \text{Max } E_2 = 41y_1 + 10y_2 \]
\[ s.t \]
\[ 121x_1 + 10x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_1 + 35y_2 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]

b. Model DEA to calculate the Factory C 2014’s efficiency

\[ \text{Max } E_3 = 11y_1 + 10y_2 \]
\[ s.t \]
\[ 13x_1 + 3x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_1 + 35y_2 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]

c. Model DEA to calculate the Factory D 2014’s efficiency

\[ \text{Max } E_4 = 35y_1 + 35y_2 \]
\[ s.t \]
\[ 77x_1 + 2x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_1 + 35y_2 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]
Appendix 3. Model Data Envelopment Analysis (continued)

d. Model DEA to calculate the Factory A 2015’s efficiency

\[ \max E_5 = 39y_1 + 40y_2 \]

s.t

\[ 212x_1 + 10x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_2 + 35y_1 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]

e. Model DEA to calculate the Factory B 2015’s efficiency

\[ \max E_6 = 59y_1 + 57y_2 \]

s.t

\[ 121x_1 + 5x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_2 + 35y_1 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]

f. Model DEA to calculate the Factory C 2015’s efficiency

\[ \max E_7 = 10y_1 + 10y_2 \]

s.t

\[ 121x_1 + 10x_2 = 1, \]
\[ 65y_2 + 79y_1 - 212x_1 - 10x_2 \leq 0 \]
\[ 41y_1 + 10y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 11y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 35y_2 + 35y_1 - 77x_1 - 2x_2 \leq 0 \]
\[ 39y_1 + 40y_2 - 212x_1 - 10x_2 \leq 0 \]
\[ 59y_1 + 57y_2 - 121x_1 - 5x_2 \leq 0 \]
\[ 10y_1 + 10y_2 - 13x_1 - 3x_2 \leq 0 \]
\[ 8y_1 + 10y_2 - 77x_1 - 2x_2 \leq 0 \]
Appendix 3. Model Data Envelopment Analysis (continued)

g. Model DEA to calculate the Factory D 2015’s efficiency

\[
\text{Max } E_8 = 8y_1 + 10y_2
\]

s.t

\[
\begin{align*}
77x_1 + 2x_2 &= 1, \\
65y_2 + 79y_1 - 212x_1 - 10x_2 &\leq 0, \\
41y_1 + 10y_2 - 121x_1 - 5x_2 &\leq 0, \\
11y_1 + 10y_2 - 13x_1 - 3x_2 &\leq 0, \\
35y_1 + 35y_2 - 77x_1 - 2x_2 &\leq 0, \\
39y_1 + 40y_2 - 212x_1 - 10x_2 &\leq 0, \\
59y_1 + 57y_2 - 121x_1 - 5x_2 &\leq 0, \\
10y_1 + 10y_2 - 13x_1 - 3x_2 &\leq 0, \\
8y_1 + 10y_2 - 77x_1 - 2x_2 &\leq 0.
\end{align*}
\]
Appendix 4. Model Fully Fuzzy Data Envelopment Analysis

a. Model Fuzzy DEA to calculate Factory B 2014’s efficiency

\[
\text{Max } \overline{E}_2 = 31u_1 + 5u_2 + 36s_1 + 7s_2 + 41t_1 + 10t_2
\]

s.t

\[
\begin{align*}
110v_1 + 3v_2 & \leq 1, \\
115l_1 + 4l_2 & \leq 1, \\
121d_1 + 5d_2 & \leq 1, \\
55u_1 + 35u_2 - 212d_1 - 10d_2 & \leq 0, \\
31u_1 + 5u_2 - 121d_1 - 5d_2 & \leq 0, \\
5u_1 + 5u_2 - 13d_1 - 3d_2 & \leq 0, \\
25u_1 + 15u_2 - 77d_1 - 2d_2 & \leq 0, \\
60s_1 + 504s_2 - 205l_1 - 9l_2 & \leq 0, \\
36s_1 + 7s_2 - 115l_1 - 4l_2 & \leq 0, \\
8s_1 + 7s_2 - 12l_1 - 2l_2 & \leq 0, \\
30s_1 + 25s_2 - 75l_1 - 2l_2 & \leq 0, \\
65t_1 + 79t_2 - 200v_1 - 8v_2 & \leq 0, \\
41t_1 + 10t_2 - 110v_1 - 3v_2 & \leq 0, \\
11t_1 + 10t_2 - 10v_1 - 2v_2 & \leq 0, \\
35t_1 + 35t_2 - 70v_1 - 2v_2 & \leq 0, \\
u_1 & \geq 0, \\
s_1 & \geq 0, \\
u_2 & \geq 0, \\
s_2 & \geq 0, \\
v_1 & \geq 0, \\
v_2 & \geq 0.
\end{align*}
\]

b. Model Fuzzy DEA to calculate Factory C 2014’s efficiency

\[
\text{Max } \overline{E}_3 = 5u_1 + 5u_2 + 8s_1 + 7s_2 + 11t_1 + 10t_2
\]

s.t

\[
\begin{align*}
10v_1 + 2v_2 & \leq 1, \\
12l_1 + 2l_2 & \leq 1, \\
13d_1 + 3d_2 & \leq 1, \\
55u_1 + 35u_2 - 212d_1 - 10d_2 & \leq 0, \\
31u_1 + 5u_2 - 121d_1 - 5d_2 & \leq 0, \\
5u_1 + 5u_2 - 13d_1 - 3d_2 & \leq 0, \\
25u_1 + 15u_2 - 77d_1 - 2d_2 & \leq 0, \\
60s_1 + 504s_2 - 205l_1 - 9l_2 & \leq 0, \\
36s_1 + 7s_2 - 115l_1 - 4l_2 & \leq 0, \\
8s_1 + 7s_2 - 12l_1 - 2l_2 & \leq 0, \\
30s_1 + 25s_2 - 75l_1 - 2l_2 & \leq 0, \\
65t_1 + 79t_2 - 200v_1 - 8v_2 & \leq 0, \\
41t_1 + 10t_2 - 110v_1 - 3v_2 & \leq 0, \\
u_1 & \geq 0, \\
v_2 & \geq 0, \\
v_1 & \geq 0, \\
v_2 & \geq 0, \\
u_1 & \geq 0, \\
u_2 & \geq 0, \\
v_1 & \geq 0, \\
v_2 & \geq 0.
\end{align*}
\]
Appendix 4. Model Fully Fuzzy Data Envelopment Analysis (continued)

c. Model Fuzzy DEA to calculate Factory D 2014’s efficiency

\[
\text{Max } \bar{F} = 25\bar{u}_1 + 15\bar{u}_2 + 30\bar{v}_1 + 25\bar{v}_2 + 35\bar{u}_1 + 35\bar{v}_2
\]
Appendix 4. Model Fully Fuzzy Data Envelopment Analysis (continued)

d. Model Fuzzy DEA to calculate Factory A 2015’s efficiency

$$\max \ \overline{E}_{5} = 39u_{1} + 40u_{2} + 101s_{1} + 74s_{2} + 212t_{1} + 212t_{2}$$

s.t

\begin{align*}
200v_{1} + 8v_{2} & \leq 1, \\
205l_{1} + 9l_{2} & \leq 1, \\
212d_{1} + 10d_{2} & \leq 1, \\
29u_{1} + 20u_{2} - 212d_{1} - 10d_{2} & \leq 0, \\
49u_{1} + 25u_{2} - 121d_{1} - 5d_{2} & \leq 0, \\
5u_{1} + 5u_{2} - 13d_{1} - 3d_{2} & \leq 0, \\
5u_{1} + 5u_{2} - 77d_{1} - 2d_{2} & \leq 0, \\
35s_{1} + 30s_{2} - 205l_{1} - 9l_{2} & \leq 0, \\
55s_{1} + 45s_{2} - 115l_{1} - 4l_{2} & \leq 0, \\
8s_{1} + 7s_{2} - 12l_{1} - 2l_{2} & \leq 0, \\
7s_{1} + 7s_{2} - 75l_{1} - 2l_{2} & \leq 0, \\
39t_{1} + 40t_{2} - 200v_{1} - 8v_{2} & \leq 0, \\
59t_{1} + 57t_{2} - 110v_{1} - 3v_{2} & \leq 0, \\
10t_{1} + 10t_{2} - 10v_{1} - 2v_{2} & \leq 0, \\
8t_{1} + 10t_{2} - 70v_{1} - 2v_{2} & \leq 0, \\
u_{1} - s_{1} & \leq 0, \\
s_{1} - t_{1} & \leq 0, \\
u_{2} - s_{2} & \leq 0, \\
s_{2} - t_{2} & \leq 0, \\
v_{1} - d_{1} & \leq 0, \\
d_{1} - l_{1} & \leq 0, \\
v_{2} - d_{2} & \leq 0, \\
d_{2} - l_{2} & \leq 0, \\
u_{1} & \geq 0, \\
u_{2} & \geq 0, \\
v_{1} & \geq 0, \\
v_{2} & \geq 0.
\end{align*}

e. Model Fuzzy DEA to calculate Factory B 2015’s efficiency

$$\max \ \overline{E}_{6} = 49u_{1} + 25u_{2} + 55s_{1} + 45s_{2} + 59t_{1} + 57t_{2}$$

s.t

\begin{align*}
110v_{1} + 3v_{2} & \leq 1, \\
115l_{1} + 4l_{2} & \leq 1, \\
121d_{1} + 5d_{2} & \leq 1, \\
29u_{1} + 20u_{2} - 212d_{1} - 10d_{2} & \leq 0, \\
49u_{1} + 25u_{2} - 121d_{1} - 5d_{2} & \leq 0, \\
5u_{1} + 5u_{2} - 13d_{1} - 3d_{2} & \leq 0, \\
5u_{1} + 5u_{2} - 77d_{1} - 2d_{2} & \leq 0, \\
35s_{1} + 30s_{2} - 205l_{1} - 9l_{2} & \leq 0, \\
55s_{1} + 45s_{2} - 115l_{1} - 4l_{2} & \leq 0, \\
8s_{1} + 7s_{2} - 12l_{1} - 2l_{2} & \leq 0, \\
7s_{1} + 7s_{2} - 75l_{1} - 2l_{2} & \leq 0, \\
39t_{1} + 40t_{2} - 200v_{1} - 8v_{2} & \leq 0, \\
59t_{1} + 57t_{2} - 110v_{1} - 3v_{2} & \leq 0, \\
10t_{1} + 10t_{2} - 10v_{1} - 2v_{2} & \leq 0, \\
8t_{1} + 10t_{2} - 70v_{1} - 2v_{2} & \leq 0, \\
u_{1} - s_{1} & \leq 0, \\
s_{1} - t_{1} & \leq 0, \\
u_{2} - s_{2} & \leq 0, \\
s_{2} - t_{2} & \leq 0, \\
v_{1} - d_{1} & \leq 0, \\
d_{1} - l_{1} & \leq 0, \\
v_{2} - d_{2} & \leq 0, \\
d_{2} - l_{2} & \leq 0, \\
u_{1} & \geq 0, \\
u_{2} & \geq 0, \\
v_{1} & \geq 0, \\
v_{2} & \geq 0.
\end{align*}
f. Model Fully Fuzzy DEA to calculate Factory C 2015’s efficiency

$$\max \tilde{E}_7 = 5u_1 + 5u_2 + 8s_1 + 7s_2 + 10t_1 + 10t_2$$

s.t

$$10v_1 + 2v_2 \leq 1,$$
$$12l_1 + 2l_2 \leq 1,$$
$$13d_1 + 3d_2 \leq 1,$$
$$29u_1 + 25u_2 - 212d_1 - 10d_2 \leq 0,$$
$$49u_1 + 25u_2 - 121d_1 - 5d_2 \leq 0,$$
$$5u_1 + 5u_2 - 13d_1 - 3d_2 \leq 0,$$
$$5u_1 + 5u_2 - 77d_1 - 2d_2 \leq 0,$$
$$35s_1 + 30s_2 - 205l_1 - 9l_2 \leq 0,$$
$$55s_1 + 45s_2 - 115l_1 - 4l_2 \leq 0,$$
$$8s_1 + 7s_2 - 12l_1 - 2l_2 \leq 0,$$
$$7s_1 + 7s_2 - 75l_1 - 2l_2 \leq 0,$$
$$39t_1 + 40t_2 - 200v_1 - 8v_2 \leq 0,$$
$$59t_1 + 57t_2 - 110v_1 - 3v_2 \leq 0,$$
$$10t_1 + 10t_2 - 10v_1 - 2v_2 \leq 0,$$
$$8t_1 + 10t_2 - 70v_1 - 2v_2 \leq 0,$$
$$u_1 - s_1 \leq 0,$$
$$s_1 - t_1 \leq 0,$$
$$u_2 - s_2 \leq 0,$$
$$s_2 - t_2 \leq 0,$$
$$v_1 - d_1 \leq 0,$$
$$d_1 - l_1 \leq 0,$$
$$v_2 - d_2 \leq 0,$$
$$d_2 - t_2 \leq 0,$$
$$u_1 \geq 0,$$
$$u_2 \geq 0,$$
$$v_1 \geq 0,$$
$$v_2 \geq 0.$$
Appendix 4. Model Fully Fuzzy Data Envelopment Analysis (continued)

g. Model Fuzzy DEA to calculate Factory D 2015’s efficiency

\[ \text{Max } \tilde{E}_D = 5u_1 + 5u_2 + 7s_1 + 7s_2 + 8t_1 + 10t_2 \]

\[ s.t. \]
\[ 70v_1 + 2v_2 \leq 1, \]
\[ 75l_1 + 2l_2 \leq 1, \]
\[ 77d_1 + 2d_2 \leq 1, \]
\[ 29u_1 + 20u_2 - 212d_1 - 10d_2 \leq 0, \]
\[ 49u_1 + 25u_2 - 121d_1 - 5d_2 \leq 0, \]
\[ 5u_1 + 5u_2 - 13d_1 - 3d_2 \leq 0, \]
\[ 5u_1 + 5u_2 - 77d_1 - 2d_2 \leq 0, \]
\[ 35s_1 + 30s_2 - 205l_1 - 9l_2 \leq 0, \]
\[ 55s_1 + 45s_2 - 115l_1 - 4l_2 \leq 0, \]
\[ 8s_1 + 7s_2 - 12l_1 - 2l_2 \leq 0, \]
\[ 7s_1 + 7s_2 - 75l_1 - 2l_2 \leq 0, \]
\[ 39t_1 + 40t_2 - 200v_1 - 8v_2 \leq 0, \]
\[ 59t_1 + 57t_2 - 110v_1 - 3v_2 \leq 0, \]
\[ 10t_1 + 10t_2 - 10v_1 - 2v_2 \leq 0, \]
\[ 8t_1 + 10t_2 - 70v_1 - 2v_2 \leq 0, \]
\[ u_1, s_1, t_1 \leq 0, \]
\[ u_2, s_2 \leq 0, \]
\[ s_2, t_2 \leq 0, \]
\[ v_1, d_1 \leq 0, \]
\[ d_1, l_1 \leq 0, \]
\[ v_2, d_2 \leq 0, \]
\[ d_2, l_2 \leq 0, \]
\[ u_1, v_1, u_2, v_2 \geq 0. \]
Appendix 5. Result Application of Lingo Software for Factory A 2014
BIOGRAPHY

Lena Puspita Sari was born on July 25th, 1994 at Buntok, Central Kalimantan, Indonesia. She is the second child of Safrudin and Mahdini. She completed her elementary education at 5 Buntok Public Elementary School, her junior high education at 1 Buntok Public Junior High School, and her senior high education at 1 Buntok Public Senior High School. She was accepted at Department of Agroindustrial Technology, Bogor Agricultural University in mid of 2012 through BUD program.

During her study in the Department of Agroindustrial Technology, she was mandated to be Analysis of Agroindustry Materials and Products lab assistant, System Analysis and Decision Making course assistant, and Industrial Equipment lab assistant. Her organizational experience is achieved through her participation in PASKIBRA of Bogor Agricultural University’s, Sports Department of BEM Fateta at 2014 as a treasurer, Sports Department of BEM Fateta in 2015 as a secretary and Fateta female basketball as manager. She is very interested in sport and write. She was awarded bronze medal representing her class on mix doubles of badminton tournament in TPB Cup 2013, second winner on flash story writing competition in TPB, get a free book on the writing competition about Dad’s days, bronze medal representing her faculty on basketball tournament in OMI 2015, silver medal representing her department on aerobic tournament in Reds Cup 2014, silver medal representing her department on female Futsal tournament in Reds Cup 2015. She is interested in Human Resources Management.