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The Production Efficiency of Sugar factory Owned by PT Perkebunan Nusantara XI Using Data Envelopment Analysis (DEA) Approach

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Abstract: *This research was carried out to 15 sugar factories (PG) owned by PT Perkebunan Nusantara XI which then became DMU (Decision Making Unit). The factories were PG Sudhono (SUD), PG Poerwodadie (PUR), PG Redjosari (RED), PG Pagotan (PAG), PG Kedawoeng (KED), PG Wonolangan (WON), PG Gending (GEN), PG Padjarakan (PAD), PG Jatiroto (JAT), PG Semboro (SEM), PG Wringin anom (WRI), PG Olean (OLE), PG Panjie (PAN), PG Pradjekan (PRA), and PG Asembagoes (ASE). The aim to know the factory efficiency and if the input variable could be used to enhance the sugar production efficiency. The analysis of efficiency value was using Data Envelopment Analisis (DEA). DEA analyzed the efficiency level of input and output variables. The level of efficiency was analyzed using three scales, namely scale efficiency, technical efficiency (CRS) and pure technical efficiency (VRS). The Efficiency Scale was obtained by comparing the CRS and VRS efficiency value. From the CRS analysis, it was found that 60% of sugar factories were operated inefficiently, while 40% were operated efficiently. The value of efficiency based on VRS analysis showed that 100% of sugar factoriess operated in efficient conditions. This inefficiency was influenced by input variables consisting of milled sugarcane, milled capacity, permanent labor, PKWT workforce, seasonal labor, daily labor, outsourced labor, stopping time A, stopping time B.*

Keywords*: Data Envelopment Analysis, Decision Making Unit, sugar factory, PT Perkebunan Nusantara XI, efficiency*

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I. Introduction

Background of Study

Sugar is one of the strategic basic needs for Indonesian people. The demand for sugar keeps increasing each year in line with the growth of population and industry which needs sugar. For the last eight years, sugar production has increased to 2,25% by the average volume of 2.713.171 ton. On the other side, the demand for sugar has increased approximately 5,78% with the average of 2.925.462 ton. Therefore, there is a deficit that has to be covered for 7,82 % or 212.921 ton. This deficiency of sugar production can be an infestation opportunity to increase the production capacity of sugar factory.

PT Perkebunan Nusantara XI or PTPN XI is a state-owned enterprise (BUMN) in agribusiness plantation with sugar as its core business. It is the only BUMN which seeks a single commodity: sugar, with a contribution of around 16-18% of national production. PT Perkebunan Nusantara XI has 16 sugar factories which are spread throughout East Java. In 2016 PT Perkebunan Nusantara XI produced sugar totaling 319,913.1 tons and molasses for 235,277.1 tons. Research on the efficiency of sugar production has been carried out by Sessu, (2016), Lilis, Ernawati dan Suryani (2013), Nazmul (2015) dan Oliveira dkk. (2013).

Increasing the efficiency of sugar factories will have an impact on the increase of farmer's income, fulfillment of national sugar needs and increase of employment. Whereas, factors which inhibit the efficiency of sugar factory production are old factory, decreased sugarcane planting area, low sugar prices which cause sugar imports, and trouble in finding suitable land to increase production, especially in Java. From the results of the analysis using multiple linear regression, it was found that sugar production has a positive correlation with the total sugarcane planting area and has a negative correlation with imported sugar (Sessu, 2016)

Lilis, Ernawati and Suryani (2013) concluded that the factors which influence the productivity and efficiency of sugar factories are the amount of yield, milling capacity, the increase of yield, and production capacity which can increase sugar production by 5% and reduce imported sugar dependence by 17%. The yield can be increased from on-farm and off-farm improvement through improved activity and additional milling capacity so that production becomes more efficient and a lot of sugar cane will not have a delay during the

milling process to the mill station. Oliveira et al. (2013) conducted a study to evaluate the efficiency of sugar production in Brazil by using DEA. A total of 17 DMUs were considered in the study for the period 2010- 2011. The inputs used in this study were: land, raw materials, costs of harvesting, and transportation of sugarcane. The output was income from selling sugar. The result showed that there was a relationship between crop productivity and profit. Six DMUs that proved to be efficient among the 17 DMUs were considered as benchmarks for increasing the productivity of other DMUs.

Nazmul (2015) assessed the efficiency of sugar factory production in Bangladesh by using DEA. In measuring efficiency, the amount of sugar produced was used as the dependent variable (output) while sugar cane planting period and milling time were used as input variables. The results showed that 99.6% of the variation in the output variable was explained the input variable. The use of DEA based on the CRS technology assumption resulted in an average production efficiency value of 0.97 for sugar factories. It indicated that, on average, factories with 3% of the efficient limit indicated that output could be increased by 3% by using available inputs

Based on the description above, this research studied about (a) if the sugar factory owned by PT Perkebunan Nusantara XI had high efficiency and (b) if the input variables could be used to increase production efficiency. If the input variable affected the increase in efficiency and the DEA analysis showed the level of efficiency of each sugar factory, then the next step was to analyze which variable strategy would be added and reduced. Here, the result would be used to determine recommendations for increasing sugar production.

II. Research Method

Methodology

This research used descriptive analysis method to determine the production efficiency in sugar mills factory owned by PT Perkebunan Nusantara XI. This research was conducted by purposive method in sugar factory owned by PT Perkebunan Nusantara XI which all located in East Java it was carried out by collecting timeseries data for the last 5 years (2013-2017) which included input variables consisting of: milled sugarcane (tons), milling capacity (tons / day), permanent workforce (people), PKWT workforce (people), seasonal workforce (people), daily labor (people), outsourced labor (people), stopping time A, stopping time B, and output variables which consisted of: sugar belonging to sugar factory (tons) and molasses belonging to sugar factory (Ton).

The efficiency analysis of sugar production at PT Perkebunan Nusantara XI used Data Envelopment Analysis (DEA). The DEA approach is known as two models of approaches based on the relationship between input variables and output, namely the CRS (Constant Returns to Scale), model and VRS (Variable Returns to Scale) model, the model with CRS conditions indicates that the input to the production factor will not have an impact in additional production (ouput). While the model with VRS conditions will show that the addition of a number of factors of production (input) will provide an increase or decrease in production capacity (output). The steps in the DEA analysis are: descriptive statistical testing, testing the correlation between variables and non-parametric analysis using DEA, and the model used in this research was as follows (Cooper, et. Al, 2011)

$$\max \varphi - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$

$$\sum_{j=1}^{n} x_{ij} V_j + s_i^- = x_{in} \qquad i = 1,2, \dots, m;$$

$$\sum_{j=1}^{n} y_{rj} V_j + s_i^+ = \varphi_{in} \qquad r = 1,2, \dots, s;$$

$$V_j \geq 0 \qquad j = 1,2, \dots, n$$

Where:
Y_{rj} = number of output r produced by sugar factory j,
X_{ij} = number ofinput i used by sugar factory j,
μ_r = weight given to output r, (r=1,..., t and t is the number of output)
V_i = weight given to input i, (i = 1,..., m and m is the number of input),
n = total of sugar factories
J_0 = number of assessed sugar factories
s = slack of input and output

III. Result And Discussion

Selection Input dan Output Variables

The input and output factors which influenced sugar production at PT Perkebunan Nusantara XI would be used in DEA calculation. The input variables chosen in this study were the resources and performance of sugar factories that were directly related to production. These input variables were: milled sugarcane (tons), milled capacity (tons / day), permanent labor (people), PKWT labor (people), seasonal labor (people), daily laborers (people), outsourced labor (people), stopping time A (hours), stopping time B (hours). The output variables used in this study were variables that had a direct impact on the performance of the sugar factory. The output variables chosen had a direct impact on the profits of a sugar factory. The output variables were: sugar and mollases owned by the factories (Ton).

Descriptive Statistical Test

From the results of the statistical analysis in Table 1, it was found in the input and output variables that the average value of all variables was in the range of 76.69 to 336469.25, which were greater than the standard deviation value of 70.08 to 240993.75. It indicated that there was no fluctuation in each input and output variable. The standard deviation obtained indicated that there would be no bias that occurred from the calculation.

Correlation Test Between Variables

Data processing for correlation tests between these variables used DEA-Solver V.3 program, to test 9 input variables and 2 output variables. From the results of the correlation test between variables, a correlation matrix between input and output variables would be obtained. The relationship between variables would have a strong correlation if the correlation test results showed a value of 0.85. If the value was less than 0.85, it meant that the input and output variables did not show a strong correlation. Based on Table 2, the strong input and output variables owned by factory showed 0.996 and cane drops owned by the factory was 0.996, while the lowest is the number of ex-campaign workers and milled sugarcane which was 0.006.

Table 1. Descriptive Statistical Test Between Input and Output Variable

	Milled Sugar Cane	Milled Capacity	Permanent Labor	PKWT Labor	Seasonal Labor	Daily Labor	Outsourced Labor	Stopping time A	Stopping timeB	Sugar Owned by Factory	Mollases owned by Factory
Max	918668,32	6146,61	603,40	583,20	199,40	394,80	777,40	435,06	754,53	45209,44	26349,84
Min	130422,32	999,04	5,00	44,00	0,00	4,00	10,00	57,21	123,42	3380,34	2282,51
Average	336469,25	2465,50	207,49	207,00	76,69	163,45	200,07	237,03	286,45	11658,51	7650,71
SD	240993,75	1460,94	129,37	133,29	70,08	108,83	186,63	96,32	153,95	11250,21	6257,82

Table 2. Correlation TestBetween Input dan Output Variables

	Milled Sugar Cane	Milled Capacity	Perman-ent Labor	PKWT Labor	Seasonal Labor	Daily Labor	Outsourced Labor	Stopping time A	Stopping time B	Sugar Owned by Factory	Mollases owned by Factory
Milled Sugar Cane	1,000	0,976	0,839	0,714	-0,006	0,426	0,716	0,434	0,238	0,963	0,962
Milled Capacity	0,976	1,000	0,884	0,690	-0,051	0,521	0,699	0,397	0,110	0,958	0,965
Permanent Labor	0,839	0,884	1,000	0,638	-0,112	0,479	0,838	0,366	0,294	0,913	0,904
PKWT Labor	0,714	0,690	0,638	1,000	0,244	0,370	0,351	0,487	0,133	0,665	0,634
Seasonal Labor	-0,006	-0,051	-0,112	0,244	1,000	-0,161	-0,164	0,234	-0,131	-0,112	-0,135
Daily Labor	0,426	0,521	0,479	0,370	-0,161	1,000	0,223	0,493	0,036	0,423	0,440
Outsourced Labor	0,716	0,699	0,838	0,351	-0,164	0,223	1,000	0,127	0,566	0,835	0,808
Stopping time A	0,434	0,397	0,366	0,487	0,234	0,493	0,127	1,000	0,353	0,335	0,330
Stopping time B	0,238	0,110	0,294	0,133	-0,131	0,036	0,566	0,353	1,000	0,324	0,281
Sugar owned by Factory	0,963	0,958	0,913	0,665	-0,112	0,423	0,835	0,335	0,324	1,000	0,996
Mollases owned by Factory	0,962	0,965	0,904	0,634	-0,135	0,440	0,808	0,330	0,281	0,996	1,000

Level of Efficiency Achievement of Sugar Factory owned by PT Perkebunan Nusantara XI

Data testing was carried out with an output-oriented DEA model. This selection was based on the fact that in the sugar factory there was a close relation between input and output, and management focused on developing output with various strategies. The output-oriented model was a model where each DMU was expected to produce the largest number of outputs possible with a certain number of inputs (maximizing output). Thus, output was something that could be controlled.

Table 3. The Result of Technical and Scale Efficiency

DMU	CRS	VRS	SE	RTS
SUD	0,87	1,00	0,87	Increasing
PUR	0,81	1,00	0,81	Increasing
RED	0,79	1,00	0,79	Increasing
PAG	1,00	1,00	1,00	Constant
KED	0,94	1,00	0,94	Increasing
WON	1,00	1,00	1,00	Constant
GEN	1,00	1,00	1,00	Constant
PAD	0,70	1,00	0,70	Increasing
JAT	1,00	1,00	1,00	Constant
SEM	1,00	1,00	1,00	Constant
WRI	0,70	1,00	0,70	Increasing
OLE	0,60	1,00	0,60	Increasing
PAN	0,90	1,00	0,90	Increasing
PRA	1,00	1,00	1,00	Constant
ASE	0,99	1,00	0,99	Increasing

The table 3 above presented the analysis result by CRS which showed that 60% of the factories were inefficiently operated, while the rest 40% were in efficient performance. The inefficient sugar factories were PG Olean (60%), PG Wringinanom (70%), PG Padjarakan (70%), PG Rejoari (79%),PG Purwodadi (81%), PG Sudono (87%), PG Kedawung (94%), and PG Asembagus (99%). The efficiency value based on VRS analysis showed that 100% of the factories were working efficiently.

The scale in Table 3 showed that the same value as in its CRS value. Efficiency scale indicated the decreasing of available unit cost in an organization when it produces on higher output volume or vice versa. The efficiency scale was obtained by comparing CRS and VRS efficiency value, because CRS efficiency value represented technical efficiency while VRS was on pure technical efficiency. The similarity of the value showed Increasing Returns to Scale (IRS) condition where inefficient was under CRS assumption but efficient under VRS assumption.

Sugar factory with IRS condition must better regulate their inputs in order to provide efficient performance and achieve optimal operational size. The projection of input and output that must be regulated can be seen in Table 4 .

Inputs which affected the inefficiencies must be reduced as it was shown in Table 4, these inputs are:

1. Milled Sugar Cane

PG Panji is reducing milled sugarcane by 1.87% and PG Asembagus did it by 18.75%. The lack of efficiency in the amount of milled sugar cane would have an impact on the inefficiency of all variables. The factories which has high efficiency factories but low efficiency plant parts will be resulted in low total efficiency (Onour, 2015).

2. Milling Capacity

From Table 4, it was found that to achieve efficient production, PG Sudono must reduce its milling capacity by 30.39%, PG Purwodadi must reduce its milling capacity by 11.45%, PG Rejosari must reduce its milling capacity by 12.40%, PG Kedawung must reduce its milling capacity by 9.32%, PG Padjar must reduce its milling capacity by 17.8%, PG Wringinanom must reduce its milling capacity by 1.43%, PG Olean must reduce its milling capacity at 11.05%, and PG Panji must reduce the grinding capacity by 16.28%.

Table 4. Projection of Input and Output Variable

DATA	SUD	PUR	RED	PAG	KED	WON	GEN	PAD	JAT	SEM	WRI	OLE	PAN	PRA	ASE
Milled Sugar Cane	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	-1,87%	0,00%	-18,75%
Milled Capacity	-30,39%	-11,45%	-12,40%	0,00%	-9,32%	0,00%	0,00%	-17,88%	0,00%	0,00%	-1,43%	-11,05%	-16,28%	0,00%	0,00%
Permanent Labor	-39,29%	-32,14%	-34,49%	0,00%	-49,28%	0,00%	0,00%	-36,46%	0,00%	0,00%	-36,98%	-12,93%	0,00%	0,00%	-5,68%
PKWT Labor	0,00%	-61,55%	-50,80%	0,00%	-10,34%	0,00%	0,00%	-71,06%	0,00%	0,00%	-71,23%	-34,60%	-50,49%	0,00%	-34,92%
Seasonal Labor	-95,37%	-100,00%	0,00%	0,00%	-79,88%	0,00%	0,00%	-97,20%	0,00%	0,00%	-94,44%	-100,00%	0,00%	0,00%	-100,00%
Daily Labor	-81,46%	-30,33%	-0,42%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	-75,16%	-67,31%	0,00%	-61,90%
Outsourced Labor	-34,57%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	-3,85%	0,00%	0,00%	0,00%	-54,82%	-14,99%	0,00%	-14,49%
Stopping time A	-66,44%	-64,67%	-59,18%	0,00%	-49,97%	0,00%	0,00%	-70,89%	0,00%	0,00%	-56,89%	-84,20%	-12,93%	0,00%	-80,58%
Stopping time B	-40,86%	-40,68%	-63,12%	0,00%	0,00%	0,00%	0,00%	-75,44%	0,00%	0,00%	-71,32%	-85,20%	-59,52%	0,00%	-77,61%
Sugar owned by Factory	28,57%	28,33%	29,12%	0,00%	40,48%	0,00%	0,00%	92,55%	0,00%	0,00%	73,92%	93,37%	31,09%	0,00%	5,54%
Mollases owned by Factory	15,12%	23,34%	26,39%	0,00%	5,89%	0,00%	0,00%	43,50%	0,00%	0,00%	42,83%	66,91%	11,41%	0,00%	1,19%

Milling capacity would greatly affect the level of efficiency. Milling capacity will make an efficiency of 78.9% (Marta S, 2011). This reduction in capacity was the impact of the presence of the stopping time. This stopping time was a manifestation of machine performance and sugarcane mastery. Singh (2007) stated that sugar factories must be oriented to the ability of the machine and mastery of sugarcane rather than an increase in production capacity. The statement can be accepted because the increase in production capacity will increase the area and the amount of sugar cane controlled.

3. Labor

PG Sudono must reduce the ex-campaign labor by 95.37%, daily labor by 81.46%, outsourcing labor by 37.57%; PG Purwodadi must reduce permanent employee by 32.14%, ex-campaign labor to 100%, daily labor of 30.33%; PG Kedawung must reduce permanent labor by 49.28%, PKWT labor by 10.34%, ex-campaign labor by 79.88%; PG Padjarakan must reduce permanent labor to 36.46%, PKWT labor by 71.06%, ex-campaign labor by 97.20%, outsourcing workers by 3.85%;PG Wringinanom must reduce permanent labor by 36.98%, PKWT labor by 71.23%, seasonal labor by 94.44%, PG Olean must reduce permanent labor by 12.93%, PKWT labor by 34.60%, seasonal labor by 100%, daily labor 75.16%, outsourcing labor by 54.82%, PG Panji must reduce PKWT labor by 50.49%, daily workers by 67.31%, outsourcing labor by 14.99%, PG Asembagus must reduce permanent employee of 5.68%, PKWT labor by 34.92%, seasonal labor by 100%, daily workers by 61.90%, and outsourcing labor by 14.49%.

One of the weaknesses of sugar factories owned by PT Perkebunan Nusantara XI is the high number of labors. The amount of labor will affect the cost of production. Sugar factories in India must reduce 43% to achieve production efficiency (Singht, 2007). The efficiency of sugar production can be caused by the number of workers. Labor has a negative effect on sugar production, with a level of 95% of labor having a significant effect on sugar production (Shinta and Pratiwi, 2011). This reduction in labor must be followed by the use of modern equipment. The use of modern equipment will help streamline labor, production costs because it will provide convenience in work and increase the company's output.

4. Milling Stopping Time

One of the reasons for the low efficiency of sugar factory was the high stopping time. The stopping time is caused not only because of the damage to the machine/ tool (internal factor), but also because of external causes, especially the supply of sugar cane to the factory (Subiyanto, 2014). PG Sudono must reduce the stopping time A by 66.44% and stopping time B by 40.86%, PG Purwodadi must reduce stopping time A by 64.67% and stopping time B by 40.68%, PG Rejosari must reduce stopping time A by 59.18% and stopping time B by 63.12%, PG Kedawung must reduce stopping time A by 49.97%, PG Padjarakan must reduce stopping time A by 70.89% and stopping time B by 75 , 44%, PG Wringinanom must reduce stopping time A by 56.89% and stopping time B by 71.32%, PG Olean must reduce stopping time A by 84.20% and stopping time B by 85.20%, PG Panji must reducestopping time A by 12.93% and stopping time B by 59.52%, PG Asembagus

must reduce stopping time A by 80.58% and stopping time B by 5.54%. This milling stopping time can be suppressed by good maintenance. Regular and good equipment management will make factory equipment to operate efficiently (Russell, 2009). The aim of maintenance management is to prevent damage to factory machinery so that production can be maximized at a low cost (Shagluf. A, et al, 2014).

IV. Summary

This research took places in 15 unit of sugar factories owned by PT Perkebunan Nusantara XI, which would be a DMU (Decision Making Unit). These factories were: PG Sudhono (SUD), PG Poerwodadie (PUR), PG Redjosari (RED), PG Pagotan (PAG), PG Kedawoeng (KED), PG Wonolangan (WON), PG Gending (GEN), PG Padjarakan (PAD), PG Jatiroto (JAT), PG Semboro (SEM), PG Wringin anom (WRI), PG Olean (OLE), PG Panjie (PAN), PG Pradjekan (PRA), PG Asembagoes (ASE). The analysis used was a non-parametric analysis using Data Envelopment Analysis (DEA) by output-based Constant Returns to Scale (CRS) and output-based Variable Returns to Scale (VRS). This selection was based on the fact that in the sugar factory there was a close realtion between input and output, while the management focused on developing output with various strategies. From the analysis results, the efficiency value of CRS had a lower value than the result of VRS, which was 40%. Sugar factories operatedin an efficient conditionand 60% of sugar factories were operatedinefficiently. Whereas, VRS efficiency calculations showed that 100% of sugar factories operated efficiently. The inefficient sugar factories were PG Olean (60%), PG Wringinanom (70%), PG Padjarakan (70%), PG Rejoari (79%), PG Purwodadi (81%), PG Sudono (87%), PG Kedawung (94 %), and PG Asembagus (99%). This inefficiency was influenced by input variables which consisted of milled sugarcane (tons), milled capacity (tons / day), permanent labor (people), PKWT labor (people), seasonal labor (people), daily labor (people), outsourced labor (people), stopping time A (hours), and stopping time B (hours).

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