

TECHNICAL EFFICIENCY ANALISYS OF CAYENNE PEPPER FARMING (CASE IN PAGU, KEDIRI, EAST JAVA)

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Abstract: Low productivity due to the inability of farmers to allocate inputs and technology in full, resulting in lower of production. The present study has estimated the technical and scale efficiencies of cayenne pepper producing, found out the trend production of farmers and knew the projected inputs that must be adopted by farmers. The study is in Pagu village, Pagu Distric, Kediri Regency, Province of East Java. Primary data collected by interview cayenne farmers who became member of the farmers group. The data was analyzed with Data Envelopment Analysis (DEA) with VRS assumption and input-oriented. The results show that cayenne pepper farming on the site research technically inefficient (CRSTE = 0.482) due to the low efficiency of scale (SE = 0.509), while the value of pure efficiency already high enough (VRSTE = 0.947). There are 4 farmers with SE = 1 and 60 farmers with SE < 1. Most of the farms have been observed have increasing return to scale trend production.

Keywords: - *cayenne pepper, DEA, technical efficiency*

INTRODUCTION

East Java is the province of production center of cayenne pepper in Indonesia. Its productivity reaches about 4.85 tons per hectare. It is categorized as low compared to other provinces including West Java (12.00 tons per hectare), Central Java (7.77 tons per hectare), West Nusa Tenggara (13.76 tons per hectare), Aceh (15.17 tons per hectare), North Sumatra (7.71 tons per hectare) and Bali (9.27 ton per hectare). The low productivity is caused by the farmers' inability in fully allocating inputs as well as technology which affects on low production.

Debertin (2012) said that the production function describes the technical relationship from changing inputs as sources to outputs. The purpose of using the production function according to Gaspersz (2008) is to determine the maximum output that can be obtained based on a number of certain inputs used. The production function that often used is Cobb-Douglas production function and translog production function. The cobb-douglas

production function is a logarithmic function that is often used in the analysis of agricultural production.

Agricultural production can't be separated from the use of inputs to produce output. A combination of input usage to achieve a particular output is called technical efficiency. Technical efficiency is the ability to produce along an isoquant curve. Kumbhakar (2002) also states that technical efficiency is the ability of a producer to minimize input used in producing certain outputs. A farmer can be efficient when compared to other farmers in the use the same of type and amount input can produce higher output. Sometime farmers have technical inefficiency. Battese and Coelli (2005) suggest that this is caused on farming there are things that make constraints such as unfavorable weather, the presence of pests or diseases in plats, and other factors that cause low of production.

An analysis of technical efficiency can be employed by parametric and non-parametric approach. Parametric approach is applied with

stochastic frontier analysis (SFA). Meanwhile, non-parametric approach is employed with data envelopment analysis (DEA). SFA method has been conducted by Saptana et al (2010), Nahaeni (2012), Hassan et al (2014) and Asmara (2016) with Cobb Douglas production function. While DEA method has been done by some researchers regarding Murthy et al (2009), Chen and Xiao (2010), Weihua et al (2015) Firmana (2016) and Asmara (2016). In DEA research, technical efficiency can be done by assumption of a Constant Return to Scale (CRS) or Variable Return to Scale (VRS). By VRS assumption, it results total efficiency (CRSTE), pure efficiency (VRSTE) and scale efficiency.

Murthy et al (2009) analysis the technical efficiency of tomato production in Karnataka, India. They classify farmers into three namely small, medium and large farmers. The values of technical efficiency obtained from the DEA model consider in input-oriented model CRS. From the three categories it is known that the highest efficiency comes from medium farmers. In contrast to Murthy et al (2002), Hassan et al (2014) analyzed the technical efficiency of corn production in Nigeria with parametric and non-parametric approaches. Hassan et al used secondary data on corn production in Nigeria from 1971 to 2010. The analytical tools used are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). The results show that the average values of technical efficiency assuming CRS, VRS and with SFA model are 0,778; 0,877; and 0,641. DEA assuming CRS show that there are 6 years with full efficiency level ($TE = 1$) and assuming VRS has 15 years of production achieving full efficiency ($TE=1$). Whereas from the results of the SFA is majority production of years are in the efficiency range between 0,71 – 0,80 which is as much as 12 years.

The use of SFA or DEA methods is in accordance with the objectives of each researcher because all methods have their own strengths and weakness. This study used DEA method to estimate technical efficiency on cayenne pepper production in Pagu, Kediri, East Java. Moreover, this study aimed at facilitating policy makers to take an appropriate decision in order to increase the farmers' production.

The objectives of this research are:

1. To analyze the level efficiency of cayenne pepper by using CRS assuming,
2. To analyze the level efficiency of cayenne pepper by using VRS assuming.
3. To analyze the scale efficiency of cayenne pepper

RESEARCH METHODS

The research was done in Pagu village, Kediri Regency, East Java. Pagu village was defined purposively as it has high cayenne pepper production in Pagu district. The highest production of cayenne pepper was hold by Pagu district in Kediri at 2016. Kediri Regency was one of central production of the cayenne pepper in East Java.

The population in this research was the cayenne pepper farmers who belong to farmer group members. The sample is determined with several steps. The first is choosing the farmer group. There are four farmer groups in Pagu village, Pagu district, Kediri Regency; Karya Bakti farmer group, Sri Agung farmer group, Sumber Rejeki farmer group and Sri Rejeki farmer group. Those groups were selected randomly by lottery. The selected groups were Tani Sri Agung and Sumber Rejeki group. Furthermore, there were 32 farmers selected from each group (Sri Agung and Sumber Rejeki group). Roscoe (1975) in Wibisono (2008) explains that the guidance in determining sample in every research must be around 30 and 500. If the sample are broken down into several parts, the minimum number is 30 for each part needed. Based on that explanation, this research uses 32 samples from each farmer group with a total of 64 farmers by two groups. The sample is employed by using simple random sampling method.

The data used in this research is primary data. The data covered the farmers' household characteristics (age, education background, non-formal education, farming experience, number of family members), farm land tenure, planting patterns, input as well as output of cayenne pepper farming. Primary data was obtained with interview method with provided questionnaire.

The model used in this study was Data Envelopment Analysis (DEA). This model was used to analyze the relative efficiency of cayenne

pepper farming. The efficiency value is between 0.00 – 1.00. TE=1 indicates that cayenne pepper farming is relatively efficient and TE<1 reflects that cayenne pepper farming is relatively inefficient.

The DEA method was known as approach; CCR and BCC. CCR approach was introduced by Charnes, Cooper and Rhodes 1978 by using basic assumption constant return to scale (CRS). CRS depicts that the ratio between addition and reduction of input and output are equal. Another assumption used in the CRS model is each company or DMU operates at the optimal scale. CRS is also known as the overall technical efficiency (OTE) or total efficiency.

The second DEA model is BCC. This model was introduced by the Banker, Charnes and Cooper in 1984. The BCC assumes that not all companies/DMU can reach at optimal scale. This is due to the existence of imperfect competition, financial constraints and others. Different from CCR that uses CRS assumption, the BCC model uses the assumption of variable return to scale (VRS). This assumption means that the changes of input and output in DMU are not linear. On the other hand, the addition of one input unit is possible to increase larger or smaller from a unit. This situation allows the occurrence of increasing return to scale (IRS) or decreasing return to scale (DRS) (Cooper et al, 2002). VRS can be used for input or output orientation. Input orientation shows if the company has control to input rather than output. Meanwhile, output orientation reveals if the company has control upon the output. BCC model of DEA is frequently called as a pure technical efficiency (PTE) that systematically explained as follows:

$$\begin{aligned} & \text{Min}_{\theta, \lambda} \theta, \\ & \text{St} - qt + Q\lambda > 0, \\ & \theta x_i - x\lambda \geq 0, \\ & \Pi' \lambda = 1 \\ & \lambda \neq 0 \end{aligned}$$

where:

Π = vektor $I \times 1$

θ = proportionate reduction of input for DMU to-i

λ = weight of DMU to-j

Scale efficiency is used to measure the DMU operating scale. It has a value of 1 (SE=1) with assumption constant return to scale (CRS). If value of scale efficiency is less than 1 (SE<1), it indicates

the inefficiency scale. Mathematically, the efficiency scale can be written as follows:

$$SE = OE/TE$$

Where

SE= scale efficiency

OE= overall efficiency (CRSTE)

TE= technical efficiency (VRSTE)

If the DMU result is efficient according to VRS model but inefficiency according to the CRS model, hence the DMU has inefficiency scale. DMU is identified as efficient (SE=1) if DMU calculation shows the equal value between CRSTE and VRSTE.

RESULTS AND DISCUSSION

Farmers Characteristics

Cayenne pepper farmers in Pagu Village can generally be seen base on age, level of education, farming experience, number of family, land area, and land status. Characteristics of respondents can be seen in Table 2.

Respondents of cayenne pepper farmers in Pagu Village have an average age of 54 years. The youngest respondent age is 31 years and the oldest respondents is 80 years. The productive age groups are people aged 15-65 years. This means that the majority of cayenne pepper farmers in Pagu Village are farmers who are in productive age.

The majority of respondents of cayenne pepper farmers are elementary school graduates, as many as 35 people or 54,69 percent. The level of education will affect the ability of farmers to absorb technology and information, including influencing operational activities in the agricultural sector. Farmers with the higher education level, easier to absorb information and apply the technology received.

The average farming experience of the respondent farmers in Pagu Village is 23 years. For the lowest experiences is 1 years while the longest farming experience is 54 years. Farmers with more farming experience are able to make the best decision in allocating inputs.

Cayenne pepper farmers in Pagu Village have a variety of family member of household. Based on the results of the study it was found that the number of farmer's household ranged from 2-6 people. The number of family household can affect the size of the farmer's household expenditure. The less number of farmer's

household, will be the smaller household expenditure. But on other hand, more number of farmer's household will help save labor cost because the majority of farmers use labor in the family for the activities of cayenne pepper farming.

Land is the main factor in farming activities. The size of the land affects the amount of input used and production produced. The average land area of cayenne pepper farming in Pagu Village is 0.3 Hectares, where the smallest area is 0.04 Hectares and the largest area is 2 hectares.

Table 1. Descriptive statistics of input and output measures and of the variables for identifying factors that influence technical efficiency

Variables	Unit	Min	Max	Mean	SD
<i>Output</i>					
Cayenne pepper production	Kilogram	1750.00	23520.00	4897.52	2918.33
<i>Inputs</i>					
Seeds	Stems	21000.00	49.000	31391.22	5230.96
Nutrient content of Nitrogen (N)	Kilogram	47.00	682.73	278.06	162.09
Nutrient content of Phospat (P)	Kilogram	33.60	525.00	144.07	106.70
Nutrient content of potassium (K)	Kilogram	28.00	411.60	118.02	75.66
Solid pesticides	Kilogram	0.00	14.00	3.35	3.28
Liquid pesticides	Liter	0.00	15.75	1.97	2.84
Labor	Days	138.00	1260	493.64	193.28
<i>Variable for identifying factors that influence technical efficiency</i>					
Age of farmers	Year	31	80	54.53	10.55
Member of household	Number	2	6	3.72	1.12
Farming experience	Year	1	58	22.82	14.00
Extension participation	Number	0	12	2.34	3.12
Education level (<i>dummy</i>)	0= elementary school, 1= others	0	1	0.28	0.45
Arable land status (<i>dummy</i>)	0= own property, 1= others	0	1	0.28	0.45
Varieties	0=local, 1=superior	0	1	0.28	0.45

Source: Primary Data (2018)

Input Use

Tabel 1 shows the use of input and output cayenne pepper farming in Pagu Village. The average of seeds that used by cayenne pepper farmers is 31.392 stems/hectare. Farmers are farming with various type of variety. Cayenne pepper type is divided into hybrid and non-hybrid. One type of hybrid variety is Baskara. Non-hybrid types are divided into two types, namely local varieties and superior varieties. Local varieties consist of gandul, prentul, galunggung, prentul prayit and prentul manu.

Superior varieties consist of pusaka, cakra, samba, and tidar. All respondent farmers used cayenne pepper seeds with non-hybrid varieties both local and superior.

The majority of farmers sample using local varieties as many as 46 farmers or 71.88 percent. Others use superior varieties as many as 18 farmers or 28.12 percent. Of the local varieties most widely chosen for the cultivation of cayenne pepper in the village of Pagu is a type of gandul variety that is as many as 35 farmers or 54.69 percent.

Table 2. The variety used by the farmers

Type	Variety	Number
Local	gandul	35
	other	11
superior	pusaka	18
	other	

The difference between local varieties and superior varieties is at harvest time, harvest time and picking distance based on fruit maturity. In local varieties, harvest time ranges from 5-6 months after planting, with harvesting for 3-4 months, while picking distances based on the average maturity level are 7 days or 1 week. Different with superior varieties, the harvest time is 3-4 months after planting, with a harvest time of 2-3 months, and the distance between quotations is a span of 5 days or in other words farmers can harvest every five days.

Farmers in Pagu Village use chemical fertilizers to help grow chili plants. The fertilizer used by the majority of farmers varies. This difference is due to the level of knowledge and experience of farmers. Fertilizers used include Urea, SP36, ZA, KCl, NPK Mutiara, Phonska NPK, and petrogenic fertilizer. To facilitate the analysis of input use, researchers distinguish fertilizers based on the content of macro nutrients, namely nitrogen nutrients (N), phosphate (P) and potassium (K). Fertilizer quantity is the result of conversion of nutrient content both N, P, and K from each fertilizer used by the respondent farmers. The average nutrient content of Nitrogen (N) used by cayenne farmers is 278.06 kg/hectare. The average nutrient content of Phosphate (P) is 114.07 kg/hectare. And the average nutrient content of Potassium is 118.02 kg/hectare.

Farming activities cannot be separated from disturbances of plant pest organisms (OPT) in the form of pest or plant diseases. Some pests that commonly attack chili plants are trips, fruit flies, whitefly, aphids, mimics, mites and some other insects. While diseases that attack chili plants include fusarium wilt, bacterial wilt, fruit rot, jaundice and leaf blotches.

One of the methods carried out by farmers in Pagu Village in controlling pests and diseases is by giving pesticides. Pesticides used also vary depending on the farmer's habits or suggestions either from the head of the farmer group or the farm shop based on a variety of cayenne pepper

farms for each farmer. According to the formulation, pesticides can be divided into two, namely solid formulations (powders or granules) and liquid formulations. Several types of pesticides with solid formulations used by cayenne farmers in Pagu Village include Basoka, Antracol, Lannet, Dithane, Acrobat, bion M, matros, and furadan. Several types of pesticides with liquid formulations are Destan, Prevathon, Agrimec, Amistar-Top, Demolish, V-protec and Carbio. The average solid formulation's pesticides used by the farmers is 3.35 kg/hectare. And the average of liquid pesticides used by the farmers is 1.97 liter/hectare.

Workers on cayenne pepper farming in Pagu Village include land processing activities, planting, fertilizing, irrigation, weeding, pesticide spraying, herbicide spraying, and harvesting. The workforce used comes from labor within the family or outside the family. The average of labor used by the cayenne pepper farmers is 494.64 HOK.

Technical Efficiency of the production

Tabel 2. Efficiency analysis result

	Mean	SD
<i>Overall technical efficiency</i>	0.482	0.209
Minimum	0.155	
Maximum	1.000	
Number technically efficient	4	
<i>Pure technical efficiency</i>	0.947	0.079
Minimum	0.679	
Maximum	1.000	
Number technically efficient	34	
<i>Scale efficiency</i>	0.509	0.212
Minimum	0.155	
Maximum	1.000	
Number CRS farms	4	
Number IRS farms	60	

Technical efficiency analysis used in this study is Data Envelopment Analysis (DEA) approach with assumption of Variable Return to Scale (VRS) which is input-oriented. The variables used in this study consisted of seven input variables and one variable output on farmer respondents (DMU). The input variables were seeds, Nitrogen (N) nutrient content, Phospat (P) nutrient content, potassium (K) nutrient content, solid and liquid pesticides, and labor. The output variable was the production of cayenne pepper.

Technical efficiency value a range of 0 to 1. Farmers can be considered as technically efficient if the value is $ET = 1$, while farmers are identified as technically inefficient if the value is $ET < 1$.

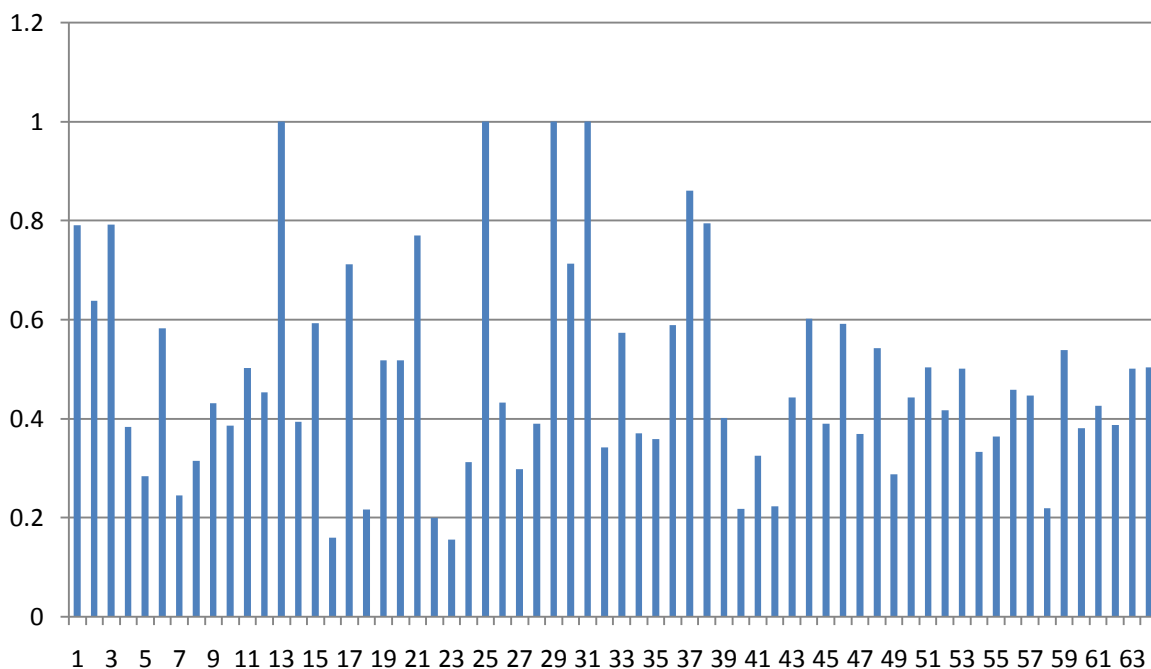
The trend of production farmers comes from the value of the scale efficiency. The results show there are 4 farmers with $SE = 1$ and 60 farmers with $SE < 1$. On 4 farmers with $SE = 1$ means that farmers have a trend of constant return to scale (CRS). Farmers who are in the position of constant return to scale (CRS) means an increase in output is equal to the amount of the addition of input. While in 60 other farmers have a trend of increasing return to scale (IRS). Farmers who are on increasing return to scale (IRS) are in the position where increased output is greater than the addition of inputs.

Based on DEA result analysis, it is revealed that the average value of overall technical efficiency (CRS assumption) of cayenne pepper is 0.482 which means that overall farmers have not been technically efficient. The lowest efficiency value is 0.155 and the highest value is 1. There were 4 farmers who have been technically efficient and the remaining 60 technically inefficient.

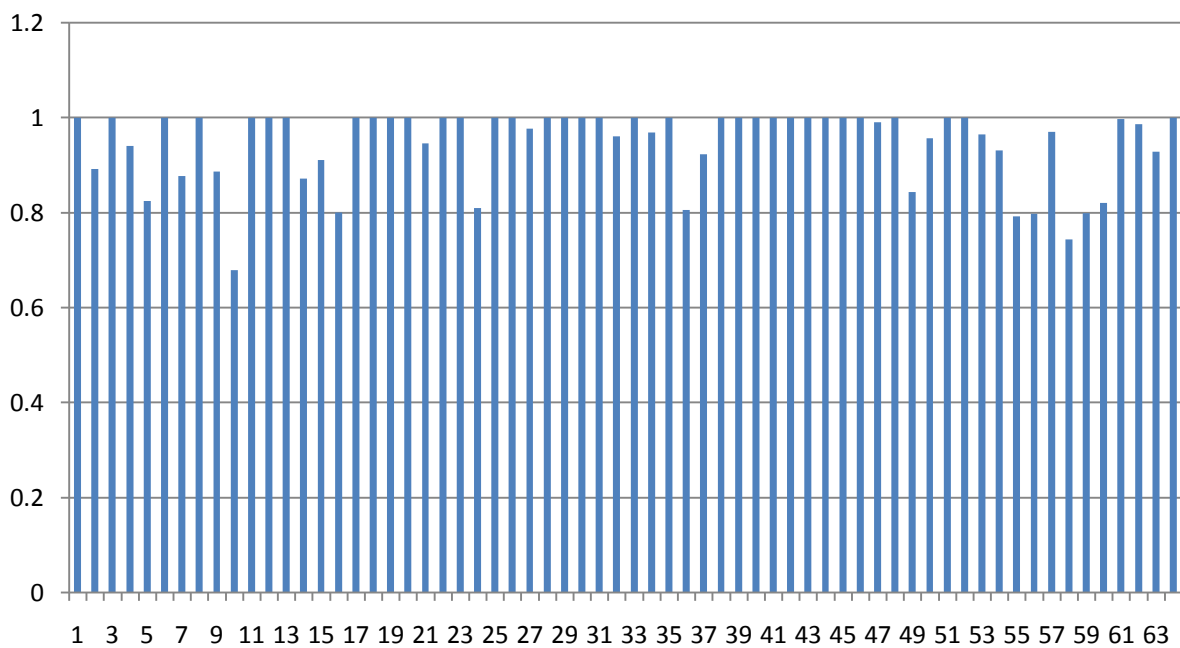
Based on the result of pure technical efficiency (VRS assumption), the average efficiency value is 0.947. The number of efficient farmers was 34 persons and other 30 farmers inefficient ($VRSTE < 1$).

Scale efficiency average is 0.509. The trend production of farmers which is obtained by the value of scale efficiency. The result revealed that there were 4 farmers with $SE = 1$ and 60 farmers with $SE < 1$. The first category, 4 farmer with $SE=1$, can be concluded that they have a trend of constant return to scale (CRS). It means that the increase of output is equal to output addition. However, other 60 farmers have a trend of increasing return to scale (IRS). Farmers in this scale, IRS, have an increase of output which is bigger than the increase of input.

The efficiency technique in this research is low ($CRSTE = 0.482$) due to the low scale efficiency ($SE = 0.509$). Nonetheless, the value of pure efficiency is high enough ($VRSTE = 0.947$). It is shown that total efficiency is caused by scale efficiency, not input allocation. Therefore, in a long term, farmers should reduce sack input but increase the scale of business to achieve the efficiency.



Picture 1. The distribution total technical inefficiency value (CRS assumption)



Picture 2. The distribution of pure technical efficiency value (VRS assumption)

CONCLUSION

Cayenne pepper in Pagu Village is technically inefficient. Technical inefficiency is caused by scale inefficiency with $SE = 0.509$. To improve technical efficiency, farmers must reduce excess inputs and increase the scale efficiency. There are 4 farmers who are technically efficient and 60 farmers technical inefficiency.

Production trends show that cayenne pepper farmers in the study location are in a state of increasing return to scale (IRS). The state of the IRS shows a return of output that is greater than the addition of input. Cayenne pepper farmers called efficient if the value of total technical efficiency as same as the value of pure technical efficiency.

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