PRODUCTION AND MARKETING EFFICIENCY OF PATCHOULI OIL INDUSTRY IN INDONESIA

E. ERNAWATI
Ph.D Scholar in Economics, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Atsiri Research Center-Pusat Unggulan Iptek Perguruan Tinggi (ARC-PUIPT) Nilam Aceh, USK, Indonesia
minaraqi@yahoo.com

Raja MASBAR
Professor, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Indonesia
raja.masbar53@gmail.com

M. Shabri Abd. MAJID*
Professor, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Indonesia
mshabri@unsyiah.ac.id
*Corresponding author

Abd. JAMAL
Associate Professor, Faculty of Economics and Business, Universitas Syiah Kuala (USK), Indonesia
abdjamal@unsyiah.ac.id

Abstract

This study aims to empirically measure and analyse the production and marketing efficiency of the patchouli oil industry in Aceh, Indonesia. The study uses primary data collected from 120 patchouli farmers and analysed using the Data Envelopment Analysis (DEA) approach. The results showed that, on average, the patchouli oil production and marketing efficiency levels were in the moderate-eficient and the low-efficient categories, respectively. The patchouli farmers have great opportunities to improve their production and marketing efficiency by optimising the use of proper inputs' combinations and agricultural intensification technologies.

Keywords: Production efficiency, Marketing efficiency, Agricultural technology, DEA
JEL classification: D24, C14, Q13

1. Introduction

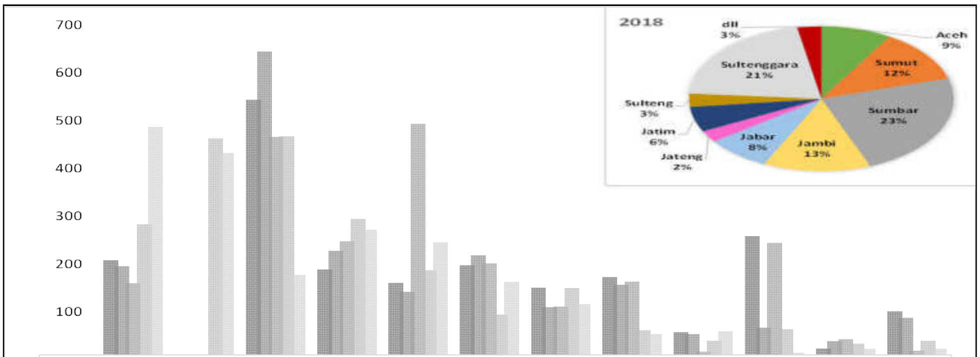
The agricultural sector is one of the most essential production sectors of the economy worldwide (Martinho et al., 2018), as it mainly contributes to the citizen's survival, welfare, and quality of life through agricultural food security (Stratigea, 2014). In Indonesia, the plantation has been viewed as one of the most important agricultural sub-sectors that play a vital role in the country (Fufurida et al., 2019) amidst the decline contribution of oil and gas to the national economy (Hurri et al., 2020). The agricultural sector consists of the sub-sector of food crops, horticulture, plantations, livestock, hunting and farming services, forestry and logging, and fisheries. This plantation sub-sector contributed 25.7% to the agricultural sector's Gross Domestic Product (GDP). It has been the only sub-sector with a positive trade balance during the period 2014-2018. Several plantation commodities have contributed significantly to the positive net export, while other agricultural sub-sectors recorded negative net exports (Agricultural Statistics, 2019).

Apart from crude palm oil (Syahril et al., 2019) and cocoa beans (Mukhlis et al., 2020), patchouli is one of the plantation commodities that have contributed a high export value to the Indonesia's economy. Patchouli is the primary sources of essential oil. Patchouli oil, known in Latin as *Pogostemon Cablin Benth*, is one of the nine leading agricultural commodities in the province that has gained international market recognition due to its high quality. Patchouli from Aceh Province can produce patchouli oil with Patchouli Alcohol (PA) content above 30%. This causes the patchouli oil from Aceh Province to be highly demanded, especially as a perfume fixative. Another immense benefit of patchouli oil is for pharmaceutical purposes, such as anti-depressants, anti-bacterial, anti-viral, anti-infective, anti-inflammatory, anti-microbial, antiseptic, disinfectant, tonic, dandruff, deodorant, dermatitis, eczema, herpes, haemorrhoids, constipation, indigestion, fatigue, infections, scars, burns, allergies, acne medication, mouth sores, and others (American College of Healthcare Science, 2012).

The international market demands patchouli oil from 1400-1600 tons per year, and this volume has been increasing about 5% annually. Meanwhile, patchouli oil supply that meets international market standards has only reached 1,000-1200 tons per year. This shows that the high potentiality of the export market for patchouli oil. As one of the largest patchouli oil-producing countries, Indonesia supplies 80% -90% of the world's demand for patchouli. Indonesia has exported patchouli oil to various countries, such as the United States, Spain, France, Switzerland, England, and other countries (Ministry of Agriculture, 2020).

Of the 34 provinces in Indonesia, four Sumatra region areas, namely Aceh, North Sumatra, West Sumatra, and Jambi, contributed 57% of Indonesia's patchouli oil in 2018. Aceh Province has been the largest patchouli producing area in Indonesia since 1921 (Puteh, 2004). In the 1980s, around 80% of Indonesia's patchouli oil supply came from Aceh Province. However, currently, Aceh Province's patchouli production has decreased significantly. Figure 1 shows that Aceh Province's patchouli production averaged only 20.98% in 2014-2018 and sharply decline to only 8.6% in 2018. This phenomenon raises an important question: why this happens? Does it relate to low-level patchouli oil in the province?

Figure 1. Patchouli oil production in Indonesia, 2015-2018 (ton)



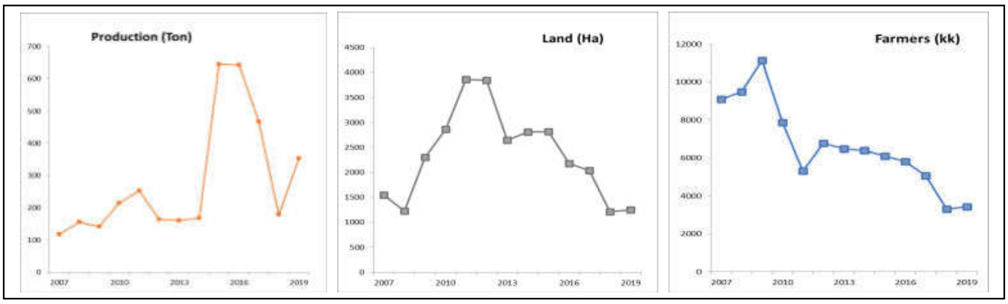
	West Sumatra	Southeast Sulawesi	Aceh	Jambi	North Sumatra	West Java	East Java	Central Java	Central Sulawesi	South Sulawesi	Gorontalo	West Sulawesi
2014	209	0	544	189	161	198	151	173	58	259	24	101
2015	196	0	645	228	142	219	110	157	54	67	39	88
2016	160	0	466	248	494	202	111	164	17	245	43	19
2017	284	463	468	295	187	95	150	62	40	64	34	40
2018	487	433	178	272	246	163	117	54	60	15	23	23

Source: Agricultural Statistics, Ministry of Agriculture, the Republic of Indonesia (2019).

On the other hand, patchouli oil demand has been notably increased globally in the last few decades. However, the patchouli farmers from Aceh Province have been unable to capture the global patchouli oil potentiality benefits by increasing their patchouli oil production. Figure 2 illustrates that the patchouli oil production in the province has been declined over the period 2015-2017, contributed mainly by the decline in their inputs, particularly the patchouli oil land area and the number of patchouli oil farmers.

Figure 2 shows that patchouli oil production has fluctuated, as is the case of its main inputs, namely land area and farmers' number. The changes in patchouli oil production inputs have not fully and positively correlated with patchouli oil production. An increase in production had occurred when the land area and the number of farmers had decreased, and vice versa. These contradicting figures raise interesting questions for the present study to research: what determines the fluctuations in the patchouli oil production in Aceh Province, Indonesia? Do the changes in patchouli oil production relate to its inefficiency? If so, to what extent is patchouli oil production's efficiency level in Aceh Province, Indonesia?

Figure 2. Patchouli production, land, and farmers in Aceh, Indonesia, 2007-2019



Source: Plantation Statistics (2020), Aceh Plantation Office.

Studies on production efficiency have been conducted by many previous researchers using both the parametric approach (Aigner et al., 1977) and the non-parametric approach (Charnes et al., 1978). These approaches have been used to measure efficiency in various fields such as industry, banking, education and agriculture. The Stochastic Frontier Approach (SFA) is the most widely used parametric approach to measure the efficiency of Decision-Making Units (DMUs) (Battese and Coelli, 1995; Choi and Weiss, 2005; Omar et al., 2006; Kokkinou, 2010; Masunda and Chiweshe, 2015; Konstantinidis and Pelagidis, 2018; and Noviar et al., 2020). Meanwhile, the Data Envelopment Analysis (DEA) approach is the most widely used non-parametric approach to measure the efficiency of DMUs (Alexander et al., 2007; Banker and Natarajan, 2008; Bremmer et al., 2008; Furtan and Sauer, 2008; Tiemann and Schreyögg, 2008; Saad et al., 2010; Keramidou et al., 2011; Riaz et al., 2013; Lee and Worthington, 2014; Cázares and Filipescu, 2014; Masunda and Chiweshe, 2015; Barbullushi and Dhuci, 2015; Majid et al., 2017; Konstantinidis and Pelagidis, 2018; Noor et al., 2020; Pougkakioti and Tsamadias, 2020; and Abidin et al., 2021).

The DEA approach has also been used to measure the efficiency of the agricultural sector in Malaysia (Shamsudin et al., 2011), Ghana (Abatania et al., 2012), Turkey (Atici and Podinovski, 2015), Indonesia (Lawalata et al., 2015), and Portugal (Marta-Costa, 2017). Especially in Indonesia, Lawalata et al. (2015) only determine the technical efficiency of red onion farming in Bantul regency, Special Province of Yogyakarta, Indonesia. However, their study did not measure the marketing efficiency and only focused on specific districts in the Special Province of Yogyakarta, Indonesia. In his research on the patchouli farm's production efficiency, Sularso (1992) only uses the Cobb-Douglas production function model and focuses only on the patchouli farm in Banyumas Regency, Indonesia. Meanwhile, Agustiar and Sa'adan (2016) analyse the efficiency level of patchouli oil marketing institutions in a village of West Aceh Regency, Aceh Province, Indonesia using marketing indicators from the marketing aspect includes marketing margin, farmers share, and the ratio of benefit to costs. Finally, in their study, Rahmayanti et al. (2018) only measure Indonesia's patchouli oil supply chain's production costs and profit margins.

Although several previous studies have explored the efficiency of patchouli oil, however, to the best of our knowledge, none of them has measured and analysed both the patchouli oil industry's production and marketing efficiency within Indonesia's broader geographical area using the DEA approach. Thus, this study aims to fill the existing gaps, aiming at empirically measuring and analysing the levels of production and marketing efficiency of patchouli oil in Aceh Province, Indonesia, using a non-parametric approach of DEA.

DEA, initially developed by Farrel (1957), is the most popular linear programming optimisation method used to measure the technical efficiency of a DMU and compare it relatively to other DMUs. DEA enables measuring the technical efficiency of one input with one output and multi-input with multiple outputs using the relative efficiency value framework as the input ratio to output (Giuffrida and Gravelle, 2001; and Post and Spronk, 1999) could offer accurate and robust efficiency measures.

This study's results are expected to be useful for patchouli stakeholders to develop the patchouli oil industry in Indonesia by improving production marketing efficiencies. The promotion of patchouli oil would enhance the contribution of the agricultural sector to the national economic performance. Especially for patchouli farmers, this study's results are also hoped to shed some lights on designing proper business development steps to promote the patchouli oil industry based on the conditions of the DMUs. Besides, this study's findings would enrich the existing empirical literature on production and marketing efficiencies of the patchouli oil industry from the world's largest patchouli oil producer of Indonesia.

The rest of the study is structured in the following sequences: Section 2 highlights research methods data employed in the study. Section 3 provides the results and their discussions, and finally, Section 4 concludes the study.

2. Research Methods

This study explores the production and marketing efficiencies of the patchouli oil industry in Aceh Province, Indonesia. The primary data are gathered from the patchouli oil farmers in the provinces using semi-structured questionnaires. Of the six zone areas, the patchouli farmers from 4 zones were selected as the study sample. According to the Regional Spatial Plan of Aceh Province (Aceh Qanun - Law No.19 of 2013 concerning Regional Spatial Plan of Aceh Province, 2013 - 2033), namely: (1) Gayo Lues Regency (Southeast Zone); (2) South Aceh Regency (South Zone); (3) Aceh Jaya District (West Zone); and (4) Aceh Utara District (North Zone) are the leading patchouli oil producer in the province. These four districts were chosen due to their largest patchouli oil production centres in each zone. These criteria include the amount of production, land productivity, and the number of patchouli farmers.

Of the 3,318 patchouli oil farmers in the province, this study's minimum sample size is determined based on the Slovin formula (Sekaran and Bougie, 2016) is only 98 respondents. However, to ensure its sample representativeness, this study selected 120 patchouli oil farmers as the study sample using the purposive sampling technique. The study sample of patchouli oil farmers was selected from the largest oil-producing district from the largest oil-producing zones' across Aceh Province, Indonesia. Only active patchouli farmers during the year 2019-2020 were randomly selected from each province's regency and zone. Besides, due to the population homogeneity, the determined sample size and the chosen respondents could represent the entire population of the patchouli oil industry in Aceh, Indonesia.

The Data Envelopment Analysis (DEA) method, developed initially by Farrel (1957), is used to measure and analyse production and marketing efficiency levels of the patchouli oil industry in Aceh Province. DEA is the most popular linear programming optimisation method used to measure a DMU's efficiency that can relatively compare it to other DMUs. DEA's advantages enable to measure the efficiency of the different number of inputs with various output (Giuffrida and Gravelle, 2001; Post and Spronk, 1999; Majid and Maulana, 2012; and Hasan et al., 2018) could offer more accurate and robust efficiency measures.

To measure the efficiency using the DEA approach needs input and output data. Referring to previous researches (Helfand, 2004; Koirala et al., 2014; Kuo et al., 2014; Mamondol, 2017; and Liu et al., 2020), this study uses land area, total capital, and the number of labour as input variables, and the amount of production as an output variable in measuring the efficiency of patchouli oil production in Aceh, Indonesia. Land, capital and labour are essential production factors (Solow, 1957) in the agricultural sector. Meanwhile, to measure the level of marketing efficiency of the patchouli oil industry in the province, the study uses input variables of marketing margins, farmers share, and the ratio of profit to cost of operating income as an output variable (Purcell, 1979; Kohls and Uhls, 2002; and Putri, et al., 2018).

Subsequently, the DEA estimation is estimated twice: (1) Assess the patchouli oil industry's production efficiency level with production variables (land, capital and labour). (2) Evaluate the patchouli oil industry's marketing efficiency level with marketing efficiency indicator variables (marketing margin, farmers share, and profit ratio to cost) in the Aceh Province, Indonesia. These DEA estimations are measured using both Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions.

2.1. CRS-DEA Model

DEA optimises the value of the function (P), which is the ratio of inputs and outputs at the same ratio limit in each DMU. The value of less than one indicates DMU is inefficiet, while the value equal to one shows efficient (Charnes et al., 1978). The linear problem for a DMU is measured as follows:

$$\text{Max P} = \left(\frac{u\prime yi}{v\prime xi}\right)$$
$$\text{u, v}$$
$$st\left(\frac{u\prime yi}{v\prime xi}\right) \leq 1 \text{ st}$$
$$\text{u, v} \geq 0\ i = 1,2, \ldots N \tag{1}$$

where *u'yi/v'xi* is the value of the function (P), *u* is an M x 1 vector of output weights, and *v* is a K x 1 vector of input weights. The objective is to find the value of *u* and *v* to maximise the ith firm's efficiency value with the constraint that all efficiency values must be less than or equal to one. Formulation of this ratio ensures that 0 < Max P < 1: the unit will be efficient if and only if this ratio is equal to one if it is not considered relatively inefficient. The model ratio formulation has an infinite number of solutions (if *u* and *v* are solutions, then α_u and α_v are solutions), so to avoid this problem, it is necessary to impose the following constraint:

vxi = 1 Maximization then becomes:

$$\max(u'yi)$$
$$\mu, \text{v}$$
$$\text{st}(v'xi) = 1$$
$$\text{u}'\text{yi} - \text{v}, \text{xj} \leq 1, \text{j} = 1,2, \ldots, \text{N} \qquad \mu, \text{v} \geq 0 \tag{2}$$

Transforming *u* and *v* to *μ* and *v* by identifying the multiplier of the linear DEA programming. Envelopes are obtained using duality in linear programming to determine a linear combination of referents for each firm to minimise the following:

$$\text{TE crs} = \min \Theta$$
$$\Theta, \lambda$$
$$\text{st} - \text{yi} + \text{Y}\lambda \geq 0$$
$$\Theta\text{xi} - \text{X}\lambda \geq 0$$
$$'\lambda \geq 0 \tag{3}$$

where *Θ* is a scale that represents the minimum level; the input usage can be reduced without changing the output level. Scale *Θ* provides general technical efficiency values for the ith company. The solution to this linear problem the analysed firms must have the same output and use only a portion of the various inputs. *Θ* can meet conditions less than or equal to 1: if equal to one, the firm is considered technically efficient (the point at the frontier) (Farrell, 1957).

2.2. VRS-DEA Model

The measurement of the VRS-DEA method distinguishes between pure technical efficiency and scale efficiency. It also enables to identify whether it is found that the yield scale is increasing, constant or decreasing. Thus, the linear CRS assumption should be changed by adding a further convexity constraint, *N1'ʎ* = 1. The VRS-DEA with input orientation could be written as follows:

$$\text{TE vrs } \Theta, ʎ = \min \Theta$$
$$\text{st} - \text{yi} + \text{Y}ʎ \geq 0$$
$$\Theta\text{xi} - \text{X}ʎ \geq 0$$
$$N1'\lambda = 1 \qquad \lambda \geq 0 \tag{4}$$

where *N1* is an *N x 1* vector from one, and *i* is the input technical efficiency value under VRS that has a value of 0 ≤ θ ≤ 1. If the value of *θ* equal to one, the firm is in the frontier, whereas λ is a *N x 1* vector weights defining the firm's linear combination of firms. The VRS-DEA model is more flexible than the CRS-DEA model. Thus, the VRS technical efficiency value is equal to or greater than the CRS technical efficiency value. These values can be used to measure the Scale Efficiency (SE) of a business:

$$\text{SE} = \frac{TEcrs}{TEvrs} \tag{5}$$

where *SE* is the scale efficiency, *TEcrs* is the technical efficiency based on the constant return to scale measurement, and *TEvrs* is the technical efficiency based on the variable return to scale measurement. SE = 1 shows scale efficiency, or SE < 1 shows scale inefficiency caused by increasing returns to scale or decreasing returns to scale. To determine whether a company is operating under Increasing Return to Scale (IRS) or Decreasing Return to Scale (DRS), the additional DEA equation of Non-Increasing Return to Scale (NIRS) is used. The previous VRS-DEA model was re-estimated by changing the restrictions from $N1'\lambda = 1$ to $N1'\lambda \leq 1$, distinguishing between the different scales in the production structure.

This study classifies the efficiency levels into five categories: optimal (full efficient), high efficient, moderately efficient, low efficient and very low (Table 1). A 100% efficiency level (EFF = 1) is considered optimal or fully efficient, while other efficiency values are categorised into different grouping levels, as illustrated in Table 1.

Table 1. Efficiency level category

Efficiency level	Category
0% < EFF < 25%	I: Very low
25% ≤ EFF < 50%	II: Low
50% ≤ EFF < 75%	III. Moderate
75% ≤ EFF < 100%	IV. High
EFF = 100%	V. Very high (Optimal)*

Note: * shows fully efficient

3. Results and Discussion

3.1. Descriptive of Patchouli Oil Farmers in Aceh, Indonesia

The study found that the average age of patchouli farmers was 39 years old, with the oldest being 80 years old and the youngest 20 years old. The most dominant generation of farmers was in the range of 20 - 40 years old (53.3%), followed by the age of 40 - 60 years old (41.7%), and the age of 60 - 80 years old (5%). Besides, the average patchouli oil farmers have 14 years of experience, with at least one year of experience and a maximum of 42 years of experience. There were 31,7% farmers with 1-5 years of farming experience; 19.2% experienced 5-10 years; 23.3% experienced 10-20 years; 17.5% experienced 20-30 years, and 8.3% have over 30 years of experience. The study also recorded that most of those with more than ten years of experience had not continuously cultivated patchouli oil farms. Sometimes, they stop farming when the demand for patchouli oil is accompanied by a low price (far from farmers' expectations) and return to cultivate patchouli farms when the price rises. Meanwhile, the average number of the patchouli oil farmers' dependents is 4, from 1–10 dependents. The most significant number of dependents of farmers was in the range of 4 - 6 people (50.8%), followed by 1-3 dependents (42.5%) and 7-10 dependents (6.7%).

The study also recorded the average size of land area used by the patchouli oil farmer annually was 0.8 Ha. Meanwhile, the farmer, on average spent IDR15,4 million for capital, involved two workers per farm annually and produced 89.4 Kg patchouli oil annually. The patchouli farmers get an average business income of IDR40.8 million and an average business profit of IDR25 million per season from the average price of patchouli oil of IDR469,000 received by farmers. Meanwhile, patchouli oil price at the exporter level reached IDR949,000 per kg. From this price difference, the farmers earned an average marketing margin of IDR480,000 with the farmers' share of 49.5%. Meanwhile, from the average income received by farmers, the ratio of profit to the average cost was 2 point.

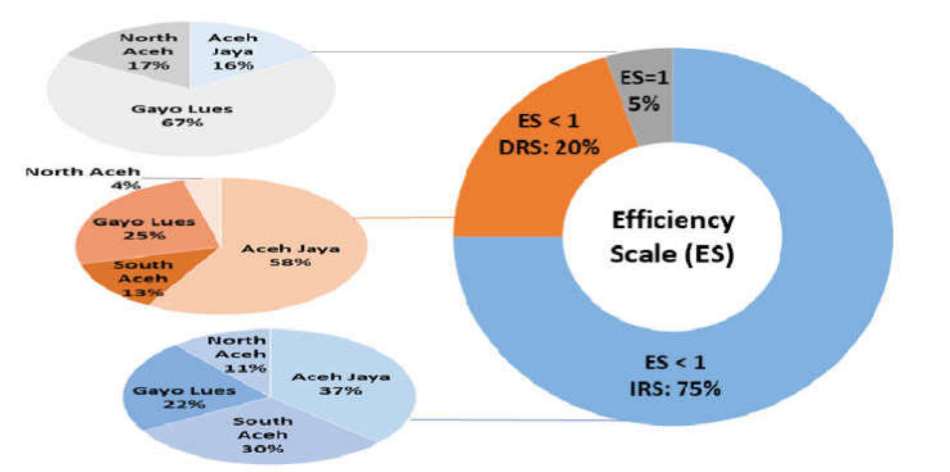
3.2. Production Efficiency Level

Table 2 (**in the Appendix**) reports the relative production efficiency level of the patchouli oil industry in Aceh Province, Indonesia, based on CRS-DEA and VRS-DEA models. The study found that patchouli oil production's relative efficiency level varied from 0.38 to 1 (38% - 100%). On average, based on the CRS-DEA and VRS-DEA models, the patchouli oil production efficiency are at the levels of 71% and 85%, respectively. Only 5.83% of the DMUs had the optimal efficiency level (EFF = 1) based on the CRS-DEA model. This shows that there were 94.17% of DMUs have experienced technical inefficiency. Meanwhile, based on the VRS-DEA approach, only 52.5% of the DMUs have experienced technical efficiency below the optimal level. These findings show that using a VRS assumption, almost half of the patchouli oil farmers in the province had run their businesses in a fully efficient.

Furthermore, Figure 3 portrays that 49.17% of the patchouli oil farmers recorded the efficiency level of 0.5 - 0.75 (50% - 75%) using the CRS-DEA model. 13.33% of them experienced a lower level of efficiency between 25% - 50%, while 31.67% of them recorded a higher level of an efficiency greater than 75% but lower than 100% (75% ≤ EFF < 100%). On the other hand, using the VRS-DEA model, 47.5% of the patchouli oil farmers enjoyed the optimal efficiency level, while 2.5% experienced an efficiency level of 25% - 50%. When viewed from the geographical area, patchouli oil farmers in Gayo Lues District recorded a higher average efficiency level than other districts with a value of 0.84 (CRS-DEA) and 0.99 (VRS-DEA). On the other hand, the patchouli oil farmers in Aceh Jaya District have recorded average efficiency levels of 0.73 (CSR-DEA) and 0.82 (VRS-DEA), respectively. The patchouli oil farmers in North Aceh District have experienced average efficiency levels of 0.68 (CSR-DEA) and 0.85 (VRS-DEA), respectively. Finally, the patchouli oil farmers in South Aceh District have only enjoyed average efficiency levels of 0.58 (CSR-DEA) and 0.77 (VRS-DEA), respectively.

From an efficiency scale perspective, the findings show that 75% of the additional inputs contributed to increased production at the increasing rate greater than the increase in additional inputs (Increasing Return to Scale - IRS). Meanwhile, the addition of input impacted increasing output with a smaller percentage increase than the additional inputs (Decreasing Return to Scale - DRS) by 20%. In detail, the conditions of IRS (75%) in the four research zones, namely: Aceh Jaya District: 36.67% (27.5%); South Aceh District: 30% (22.5%); Gayo Lues District: 22.22% (16.67%); and North Aceh District 11.11% (8.33%). Meanwhile, in DRS conditions (20%), it comprises Aceh Jaya District: 58.33% (11.67%); South Aceh District: 12.5% (2.5%); Gayo Lues District: 25% (5%); and North Aceh District 4.17% (0.83%).

Figure 3. The efficiency scale of the patchouli oil industry in Aceh, Indonesia



Source: Primary data analysed (2020).

The relatively low production efficiency level of patchouli oil can be viewed from the average ability of the land area of 0.8 Ha only to produce patchouli oil of 89.4 Kg per season. This evidence shows that the level of land productivity is only 127.2 kg of patchouli oil per ha per season (Table 3). Meanwhile, the average potential output using superior patchouli varieties, such as Tapak Tuan, Lhokseumawe, and Sidikalang varieties, could produce 350 kg per ha (Center for Plantation Research and Development, 2007). Our findings show that, on average, the actual production rate of patchouli oil in the province was only between 30% - 40%.

Table 3. Production gap of patchouli oil farmers in Aceh, Indonesia

Productivity (Kg/Ha)	Number of DMUs (%)	Mean Productivity of DMUs (Kg/Ha)	Mean of Actual Output/ Output Potential (%)
Productivity ≤ 100	41.7	82.1	23.4
100 <Productivity ≤ 200	55.8	156.2	44.6
200 <Productivity ≤ 300	2.5	233.3	66.7
Overall DMUs	100	127.2	36.4

Source: Primary data analysed (2020).

As observed from Table 3, the average DMU only has an actual production capacity of 36% compared to its potential output. There were 41.7% of DMUs with a productivity level that reached 100 Kg/Ha. At this level, the DMUs' average productivity was only 82.1 Kg/Ha, with an average comparison of actual output to potential output of 23.4%. Besides, the number of DMUs with productivity levels above 100 to 200 Kg/Ha was 55.8%, with an average DMUs' productivity of 156.2 Kg/Ha and an average comparison of actual output to potential output of 44.6%. Meanwhile, the number of DMUs with productivity levels above 200 to 300 Kg/Ha was only 2.5%, with an average DMUs' productivity of 233.3 Kg/Ha and an average comparison of actual output to potential output 66.7%.Although the relative production efficiency of DMU shows the average at a moderate level (CRS-DEA) and high level (VRS-DEA), however, their average DMU's productivity level was still low (<50% compared to potential output). The low level of productivity caused the patchouli become less competitive (Dovgal et al., 2017) and threatened its sustainablity (Vlachos and Malindretos, 2008; Marta-Costa et al., 2012; and Marta-Costa, 2017) in the global market. These findings are in line with the majority of the previous studies on agricultural commodities worldwide. For example, previous studies documented a low level of efficiency of the farming sector in Malaysia (Shamsudin et al., 2011), Ghana (Abatania et al., 2012), Turkey (Atici and Podinovski, 2015), and Indonesia (Sularso, 1992; and Lawalata et al., 2015).

The low level of production of the patchouli oil industry documented in our study is mainly due to improper combination of patchouli inputs by the DMUs, which is shown by 75% of the DMUs, were in a condition of IRS. In addition, a low production level is recorded due to their traditional production process. Thus, it is extremely important for the modernazation of patchouli industry in the region (Papadopoulou et al., 2012). In this study, the production efficiency level measurements only used three inputs, namely land, capital, and labour, and did not include technology. Thus, the findings' study did not indicate the use of technology in the patchouli oil cultivation and production process. In terms of capital, it is also only for the provision of patchouli cuttings with a direct planting pattern on the land instead of the cuttings for obtaining superior patchouli seeds and labour costs for the land clearing, planting and harvesting processes. Most of the planting and harvesting costs are also not taken into account because they are done directly by farmers and family members.

3.3. Marketing efficiency level

This section reports the findings of patchouli oil farms' marketing efficiency level in Aceh Province, Indonesia, using the CRS-DEA and VRS-DEA methods. As illustrated in Table 4 (**in the Appendix**), only 2.5% of the DMUs have an optimal efficiency level based on the CRS assumption and 3.33% based on the VRS assumption, respectively. This finding shows that only a few patchouli farmers can market the agricultural patchouli commodities fully efficient. The traditional ways of cultivating and planting patchouli are believed to be the main contributors to marketing inefficiency. In addition, the limited technological supports to process the patchouli oil have resulted in a relatively higher cost of production. Thus, the patchouli farmers must adopt advanced agricultural technologies in producing and marketing patchouli oil commodities.

The mean score of marketing efficiency between the CRS-DEA and the VRS-DEA, as illustrated in Table 4, has almost similar mean value (CRS = 0.3381 and VRS = 0.3382); thus, this shows the efficiency scale is equal to one. The scale efficiency score is measured by comparing the value of the CRS-DEA's efficiency and the VRS-DEA's efficiency. This finding shows an impossibility of further increasing efficiency scale because only 1.67% of DMUs were in a condition of increasing return to scale. Using marketing indicators as input variables for measuring marketing efficiency in both models might contribute to a scale efficiency score equal to one. In contrast, the production inputs used for measuring production efficiency causes the CRS-scale efficiency and VRS-scale efficiency to be dissimilar (Table 2 **in the Appendix**).

Furthermore, the study found 89.17% of DMUs recorded a relative high marketing inefficiency level of below 50%. Meanwhile, 6.67% of DMUs have enjoyed a higher level of marketing efficiency within the range of 50% to 75% (in both models). Only 1.66% (CRS-DEA) and 0.83% (VRS-DEA) of the DMUs have experienced an efficiency level above 75% and below 100% (0.75<EFF<1.00). Overall, the average level of marketing efficiency in both models was 33.8%. The low level of marketing efficiency is mainly due to the relatively low price of patchouli oil at the farmer level, far below their expectations. This fact can be viewed from the farmers' share, which was below 50%. Our findings of the low level of marketing efficiency of the patchouli oil industry in Aceh, Indonesia, are in harmony with previous studies investigating the marketing efficiency of watermelon farms in Nigeria (Onyemauwa, 2010) and the potato market in Uganda (Kyomugisha et al., 2018).

These findings imply that the development of the patchouli oil industry in Aceh Province has a huge opportunity to improve its marketing efficiency level. These farmers have a chance to improve their marketing efficiency level by 72.2%. This massive opportunity for improving marketing efficiency could be done by optimising the combination of appropriate inputs, adopting advanced agricultural-related technologies, and intensifying the planting seasons of patchouli. Efforts are needed to ensure patchouli oil price stability at the farmers' level to ensure their survival and improve their welfare.

Finally, the supply and marketing chains should be controlled and regulated to avoid unnecessary additional costs of patchouli production and marketing activities. The supply chain of patchouli oil has been the major problem in Indonesia (Rahmayanti et al., 2018), thus needs to be regulated. Marketing the patchouli oil through middlemen (patchouli agents) should also be monitored for them did not monopolise the market and control over price. The patchouli farmers deserve to enjoy more profit margin rather than their agents. Thus, the relevant government authorities, such as the Ministry of Agriculture and the Patchouli Oil Association, should design strategic policies for the patchouli farmers' maximum benefits.

4. Conclusion

The study empirically measured and analysed the patchouli oil industry's production and marketing efficiency in Aceh, Indonesia, using the Data Envelopment Analysis (DEA) approach. The study found that, on the production side, the average efficiency level of the patchouli oil industry in the province was relatively low based on both Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions. Very few patchouli farmers have recorded their production efficiency at the optimal level.

On the marketing side, the low marketing efficiency for the patchouli oil industry is also recorded. The majority of patchouli farmers recorded low marketing efficiency level, and very few of the farmers had experienced an optimal or entirely marketing efficiency. These findings showed that the patchouli farmers have an excellent opportunity to improve their production and marketing efficiency by properly mixes the inputs to produce maximum outputs and controls supply and marketing chains by being monopolised by middlemen (patchouli agents).

The low level of patchouli farmers' efficiency level in Aceh Province, Indonesia, is mainly due to traditional planting patchouli on-farm side. Thus, it is an urgent need for the government to design strategies to fully support the development of the patchouli industry by carrying out targeted and precise budgeting programs to adopt advanced technology in the patchouli agro-industry. Optimal technological intervention is expected to increase efficiency as well as productivity. Increasing efficiency is the initial stages of expanding the income of patchouli farmers. This encourages farmers to always stay in patchouli farms and ensures patchouli oil production sustainability as a potential exporting commodity.

The low level of efficiency on the marketing side indicates the low price level and profit margin received by patchouli farmers. At the same time, most of the patchouli agents' reaped the benefits from monopolising the patchouli oil commodity. Price stability at the farmer level is very crucial in determining marketing efficiency. Therefore, the government needs to act as a price stabiliser by regulating the market favouring the interests of patchouli farmers, such as by setting a minimum selling price policy to create a fair trading system that supports the patchouli's sustainability agro-industry.

Future studies on the efficiency of the patchouli oil industry in Indonesia could cover a broader area across the 34 provinces nationwide to provide a comprehensive picture of the existing efficiency condition. Examining the patchouli oil efficiency determinants could offer better references for policy-makers to design a complete strategic policy to promote patchouli oil as a primary Indonesia's export commodity to strengthen the national economy. Finally, measuring efficiency level using a combination of parametric and non-parametric approaches could also enrich existing empirical evidence on the patchouli oil industry's efficiency.

5. References

Abatania, L. N. Hailu. A., and Mugera, A. W. 2012. "Analysis of farm household technical efficiency in Northern Ghana using bootstrap DEA". Paper Presented at the 56th Annual Conference of the Australian Agricultural and Resource Economics Society. The Esplanade Hotel, Fremantle WA.7-10 February 2012. [Online]. Available: https://ageconsearch.umn.edu/record/124211/ [Accessed: 23 Jan 2020].

Abidin, Z., Prabantarikso, R. M., Wardhani, R. A., and Endri. 2021. "Analysis of Bank Efficiency between Conventional Banks and Regional Development Banks in Indonesia". Journal of Asian Finance, Economics and Business, 8(1), 741–750. https://doi.org/10.13106/jafeb.2021.vol8.no1.741

Aceh Qanun. 2019. "Qanun Aceh No. 19 Tahun 2013 tentang RTRW Aceh 2013-2033", Banda Aceh: Pemerintah Provinsi Aceh. [In Indonesia].

Agricultural Statistics. 2019. "Patchouli Oil Statistics 2019". Jakarta: Ministry of Agriculture, the Republic of Indonesia.

Agustiar, A., and Sa'adan, I. 2016. "Analisis dan Efisiensi Pemasaran Minyak Nilam di Desa Kubu Kecamatan Arongan Lambalek Kabupaten Aceh Barat". Jurnal Bisnis Tani, 2(1), 96-104. https://doi.org/10.35308/jbt.v2i1.538. [In Indonesia].

Aigner, D., Lovell, C. A. K., and Schmidt, P. 1977. "Formulation and Estimation of Stochastic Frontier Production Function Models". Journal of Econometrics, 6(1), 21-37. https://doi.org/10.1016/0304-4076(77)90052-5

Alexander, W. R. J., Haug, A. A., and Jaforullah, M. 2007. "A Two-Stage Double-Bootstrap Data Envelopment Analysis of Efficiency Differences of New Zealand Secondary Schools". Economics Discussion Papers No. 0714. The University of Otego. Available: https://ourarchive.otago.ac.nz/bitstream/handle/10523/1047/DP_0714.pdf?sequence=2&origin=publicationDetail [Accessed: 11 Feb 2020].

American College of Healthcare Science. 2012. "Essential Oil of Patchouli", Available: https://files.achs.edu/mediabank/files/achs_patchouli_monograph.pdf [Accessed: 9 Feb 2020].

Atici, K. B., and Podinovski, V. V. 2015. "Using Data Envelopment Analysis for the Assessment of Technical Efficiency of Units with Different Specialisations: An Application to Agriculture". Omega, 54, 72-83. https://doi.org/10.1016/ j.omega.2015.01. 015

Banker R. D., and Natarajan, R. 2008. "Evaluating Contextual Variable Affecting Productivity Using Data Envelopment Analysis". Operational Research, 6, 48-58. https://doi.org/10.1287/opre. 1070.0460

Barbullushi, E., and Dhuci, O. 2015. "Albanian Banking Efficiency Analysis: A Production DEA Approach-Comparision of CRS and VRS Model". Regional Science Inquiry, 7(2), 59-68.

Battese, G.E. and Coelli T. 1995. "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data". Empirical Economics, 20, 325-332. https://link.springer.com /article/10.1007/BF01205442

Bremmer, J.G., Alfons, J. M., Lansink, O. R., and Huirne, B. M. 2008. "The Impact of Innovation, Firm Growth and Perceptions on Technical and Scale Efficiency". Agricultural Economics Review, 9(2), 65-85. https://doi.org/10.22004/ ag.econ.178236

Cázares C. C., Filipescu, D. A. 2014. "Measuring the Effects of Internationalisation on Technological Innovation Efficiency". Paper Presented at the DRUID Society Conference 2014, CBS,

Copenhagen, 16-18 June 2014. [Online]. Available: https://conference.druid.dk/ acc_papers/jcp48rnj4xyvfo7oc2i4d563bhjs.pdf [Accessed: 4 Jan 2010].
Center for Plantation Research and Development. 2007. "Patchouli Oil: Prospect and Challenges". Banda Aceh: Patchouli R&D Centre.
Charnes, A., Cooper, W. W., and Rhodes, E. 1978. "Measuring the Efficiency of Decision-Making Units". European Journal of Operational Research, 2(6), 429-444. https://doi.org/10.1016/0377-2217(78)90138-8
Choi, B. P., and Weiss, M. A. 2005. "An Empirical Investigation of Market Structure, Efficiency, and Performance in Property-Liability Insurance". Journal of Risk and Insurance, 72(4), 635-673. https://doi.org/10.1111/j. 1539-6975.2005.00142.x
Cooper, W. W., Seiford, L. M., and Tone, K. 2001. "Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software". Journal of the Operational Research Society, 52(12), 408-1408.
Dovgal, O. V., Kravchenko, M. V., Demchuk, N. I., Odnoshevnaya, O. A., Novikov, O. Y., Andrusiv, U. Y., Lesik, I.M., and Popadynets, I. R. 2017. "Methods of Competitiveness Assessment of Agricultural Enterprise in Eastern Europe". Regional Science Inquiry, 9(2), 231-242.
Everest, E. A. J. 1978. "Productivity and Quality". New Jersey: Prentice Hall Inc.
Fafurida, F., Setiawan, A. B., and Oktavilia, S. 2019. "Investment Improvement Efforts in the Agricultural Sector". Regional Science Inquiry, 11(2), 49-57.
Farrell, M. J. 1957. "The Measurement of Productive Efficiency". Journal of the Royal Statistical Society (Series A), 120(3) 253–290. https://doi.org/10.2307/2343100
Furtan, W. H., and Sauer, J. 2008. "Determinants of Food Industry Performance: Survey Data and Regressions for Denmark". Journal of Agricultural Economics, 59(3), 555-573. https://doi.org/10. 1111/j.1477-9552.2008.00164.x
Giuffrida, A., and Gravelle, H. 2001. "Measuring Performance in Primary Care: Econometric Analysis and DEA". Applied Economics, 33(2), 163-175. DOI: 10.1080/00036840150209183
Hasan, I., Azhari, A., and Majid, M. S. A. 2018. "How Efficient and Productive Are Co-Operatives in Indonesia? Empirical Evidence from Data Envelopment Analysis". Revesco-Revista De Estudios Cooperativos, 128, 149-172. https://doi.org/10.5209/REVE.60208
Helfand, M, S. 2004. "Farm size and the Determinants of Productive Efficiency in the Brazilian Center-West". Agricultural Economics, 31(2-3), 241-249. DOI:10.1016/ j.agecon.2004.09.021
Hurri, S., Muhammad, S., Jamal, A., and Majid, M. S. A. 2019. "Do Exports Of Oil and Gas Still Matter for Regional Economic Growth of Sumatra, Indonesia?". Regional Science Inquiry, 11(1), 9-18.
Keramidou, I., Mimis, A., Pappa, E., and Filios, S. 2011. "Efficiency of Meat Products Industry in Greece: A Bootstrap DEA Approach". International Journal of Interdisciplinary Social Sciences, 5(9), 15-28.
Kohls, R. L., and Uhl, J. N. 2002. "Marketing of Agricultural Products" (No. Ed. 9). USA: Prentice-Hall Inc.
Koirala, K. H., Mishra, A., and Mohanty, S. 2016. "Impact of Land Ownership on Productivity and Efficiency of Rice Farmers: The Case of the Philippines". Land Use Policy, 50, 371-378. https://doi.org/10.1016/j.landusepol. 2015.10.001
Kokkinou, A. 2010. "Estimating Technical Inefficiency: An Empirical Approach to EU Industries". Regional Science Inquiry, 2(2), 95-104.
Konstantinidis, G., and Pelagidis, T. 2018. "Efficiency Measurement of 6 Major Container Ports in The West Africa Region". Regional Science Inquiry, 10(1), 63-76.
Kuo, H. F., Chen, H. L., and Tsou, K. W. 2014. "Analysis of Farming Environmental Efficiency using a DEA Model with Undesirable Outputs". APCBEE Procedia, 10, 154-158. https://doi.org/10.1016/j.apcbee.2014.10.034
Kyomugisha, H., Sebatta, C., and Mugisha, J. 2018. "Potato Market Access, Marketing Efficiency and On-Farm Value Addition in Uganda". Scientific African, 1, 14-25. https://doi.org/10.1016/j. sciaf.2018.e00013
Lawalata, M., Darwanto, D. H., and Hartono, S. 2015. "Efisiensi Relatif Usahatani Bawang Merah di Kabupaten Bantul dengan Pendekatan Data Envelopment Analysis (DEA)". Ilmu Pertanian (Agricultural Science), 18(1), 1-8. https://doi.org/10.22146/ipas.6169 [In Indonesia].
Lee, B. L., and Worthington, A. C. 2014. "Technical Efficiency of Mainstream Airlines and Low-Cost Carriers: New Evidence Using Bootstrap Data Envelopment Analysis Truncated Regression". Journal of Air Transport Management, 38, 15-20. https://doi.org/10.1016/j.jairtraman. 2013.12.013
Liu, J., Wang, M., Yang, L., Rahman, S., and Sriboonchitta, S. 2020. "Agricultural Productivity Growth and Its Determinants in South and Southeast Asian countries". Sustainability, 12(12), 1-21. https://doi.org/ 10.3390/su12124981

Majid, M. S. A., and Maulana, H. 2012. “A Comparative Analysis of the Productivity of Islamic and Conventional Mutual Funds in Indonesia: Data Envelopment Analysis (DEA) and General Least Square (GLS) Approaches”. Gadjah Mada International Journal of Business, 14(2), 183-208. DOI: 10.22146/gamaijb.5439

Majid, M., Hamid, A., and Faradila, F. 2017. “Assessing the Productivity of Insurance Companies in Indonesia: A Non-Parametric Approach”. Journal of Applied Economic Sciences, 12(6), 1593–1605. http://cesmaa.org/Docs/ JAES %20Fall%206 (52) 2017_online.pdf#page=24

Marta-Costa, A., Martinho, V., and Santos, M. 2017. “Productive Efficiency of Portuguese Vineyard Regions”. Regional Science Inquiry, 9(2), 97-107.

Marta-Costa, A., Torres-Manso, F., and Tibério, L. 2012. “Sustainability Diagnosis of an Agroforestry System”. Regional Science Inquiry Journal, 4(2), 111-124.

Martinho, V. J. P. D. 2018. “Characterization of Agricultural Systems in the European Union Regions: A Farm Dimension-Competitiveness-Technology Index as Base”. Regional Science Inquiry, 10(2), 135-152.

Masunda, S., and Chiweshe, A. R. 2015. “A Stochastic Frontier Analysis on Farm Level Technical Efficiency in Zimbabwe: A Case of Marirangwe Smallholder Dairy Farmers”. Journal of Development and Agricultural Economics, 7(6), 237-242. DOI: 10.5897/JDAE2014.0630

Mukhlis, M., Masbar, R., Syahnur, S., & Majid, M. S. A. 2020. “Dynamic Causalities between World Oil Price and Indonesia’s Cocoa Market: Evidence from the 2008 Global Financial Crisis and the 2011 European Debt Crisis”. Regional Science Inquiry, 12(2), 217-233.

Papadopoulou, E., Papalexiou, C., and Hasanagas, N. 2012. “Participatory Evaluation of Rural Development Programmes: A Qualitative Approach in the Case of Modernisation of Agricultural Holdings in Greece”. Regional Science Inquiry Journal, 4(1), 81-94.

Pougkakioti, I. D., and Tsamadias, C. 2020. “Measuring the Efficiency and Productivity Change of Municipalities: Empirical Evidence from Greek Municipalities over the Time Period 2013-2016”. Regional Science Inquiry, 12(1), 55-74.

Purcell, W. D. 1979. “Agricultural Marketing: System, Coordination, Cash, and, Futures Prices”. Virginia: A Prentice-Hall Company.

Stratigea, A. 2014. “Setting Policy Targets for the Future of Agriculture in EU 2020-A Methodological Approach”. Regional Science Inquiry, 6(1), 95-110.

Syahril, S., Masbar, R., Majid, M. S. A., and Syahnur, S. 2019. “Does Indonesia as the World Largest Palm Oil Producing Country Determine the World Crude Palm Oil Price Volatility?”. Regional Science Inquiry, 11(1), 93-104.

Vlachos, I., and Malindretos, G. 2008. “Farm SMEs Sustainability Assessment Based on Bellagio Principles. The Case of Messinian Region, Greece”. Regional Science Inquiry Journal, 4(3), 137-153.

Appendices

Table 2. The production efficiency level of patchouli oil based on DEA-CRS and -VRS models

DMU	Efficiency Level		Category		Efficiency Scale	DMU	Efficiency Level		Category		Efficiency Scale	DMU	Efficiency Level		Category		Efficiency Scale
	CRS	VRS	CRS	VRS			CRS	VRS	CRS	VRS			CRS	VRS	CRS	VRS	
1	0.704	0.708	III	III	IRS	41	0.395	0.426	II	II	IRS	81	0.481	0.679	II	III	DRS
2	0.579	0.633	III	III	IRS	42	0.483	0.500	II	III	IRS	82	0.478	0.491	II	II	IRS
3	0.955	0.978	IV	IV	IRS	43	0.616	0.681	III	III	IRS	83	0.692	1.000	III	V	IRS
4	0.396	0.500	II	III	IRS	44	0.616	0.681	III	III	IRS	84	0.421	0.500	II	III	IRS
5	0.560	0.633	III	III	IRS	45	0.559	0.531	III	III	IRS	85	0.692	1.000	III	V	IRS
6	0.744	0.754	III	IV	DRS	46	0.717	0.728	III	III	DRS	86	0.384	1.000	II	V	IRS
7	0.462	1.000	II	V	IRS	47	0.448	1.000	II	V	IRS	87	0.507	0.643	III	III	DRS
8	0.462	1.000	II	V	IRS	48	0.395	1.000	II	V	IRS	88	0.519	0.664	III	III	DRS
9	0.556	0.636	III	III	IRS	49	0.880	0.908	IV	IV	IRS	89	0.490	0.528	II	III	IRS
10	0.880	0.908	IV	IV	IRS	50	0.825	0.900	IV	IV	IRS	90	0.573	0.571	III	III	IRS
11	0.880	0.908	IV	IV	IRS	51	0.658	1.000	III	V	IRS	91	0.698	1.000	III	V	IRS
12	0.658	1.000	III	V	IRS	52	0.658	0.684	III	III	IRS	92	0.615	1.000	III	V	IRS
13	0.880	0.908	IV	IV	IRS	53	0.958	1.000	IV	V	DRS	93	0.938	1.000	IV	V	IRS
14	0.880	0.908	IV	IV	IRS	54	1.000	1.000	V	V	ES1	94	0.807	1.000	IV	V	IRS
15	0.660	0.718	III	III	IRS	55	0.526	1.000	III	V	IRS	95	0.908	1.000	IV	V	IRS
16	0.789	0.800	IV	IV	IRS	56	0.474	1.000	II	V	IRS	96	0.698	1.000	III	V	IRS
17	1.000	1.000	V	V	ES1	57	0.672	1.000	III	V	IRS	97	0.908	1.000	IV	V	IRS
18	0.817	0.912	IV	IV	IRS	58	0.933	0.957	IV	IV	IRS	98	0.786	1.000	IV	V	IRS
19	0.880	0.908	IV	IV	IRS	59	0.933	0.957	IV	IV	IRS	99	0.738	0.962	III	IV	DRS
20	0.663	0.684	III	III	DRS	60	0.896	1.000	IV	V	IRS	100	0.938	1.000	IV	V	IRS
21	0.625	0.669	III	III	DRS	61	0.585	0.593	III	III	IRS	101	0.738	0.943	III	IV	DRS
22	0.521	0.528	III	III	DRS	62	0.846	1.000	IV	V	IRS	102	0.990	1.000	IV	V	IRS
23	0.648	0.719	III	III	IRS	63	0.443	0.444	II	II	IRS	103	1.000	1.000	V	V	ES1
24	0.719	0.713	III	III	DRS	64	0.666	0.660	III	III	IRS	104	0.975	1.000	IV	V	DRS
25	0.658	1.000	III	V	IRS	65	0.662	1.000	III	V	IRS	105	0.978	1.000	IV	V	DRS
26	1.000	0.896	V	IV	IRS	66	0.692	1.000	III	V	IRS	106	0.692	1.000	III	V	IRS
27	0.987	0.924	IV	IV	IRS	67	0.556	0.554	III	III	IRS	107	0.917	1.000	IV	V	IRS
28	0.789	0.681	IV	III	IRS	68	0.738	1.000	III	V	IRS	108	0.677	1.000	III	V	IRS
29	0.719	0.713	III	III	DRS	69	0.769	1.000	IV	V	IRS	109	0.738	0.943	III	IV	DRS
30	0.599	0.607	III	III	DRS	70	0.565	0.561	III	III	IRS	110	0.917	1.000	IV	V	IRS
31	0.729	0.810	III	IV	DRS	71	0.572	0.643	III	III	IRS	111	0.615	1.000	III	V	IRS
32	0.729	0.810	III	IV	DRS	72	0.385	1.000	II	V	IRS	112	1.000	1.000	V	V	ES1
33	0.719	1.000	III	V	IRS	73	0.538	1.000	III	V	IRS	113	0.990	1.000	IV	V	IRS
34	0.719	1.000	III	V	IRS	74	0.504	0.537	III	III	IRS	114	0.769	1.000	IV	V	IRS
35	0.987	1.000	IV	V	IRS	75	0.518	0.525	III	III	IRS	115	0.615	1.000	III	V	IRS
36	0.755	0.845	IV	IV	DRS	76	0.455	0.517	II	III	IRS	116	0.738	1.000	III	V	IRS
37	0.722	0.843	III	IV	DRS	77	0.821	0.830	IV	IV	IRS	117	0.957	1.000	IV	V	DRS
38	0.729	0.810	III	IV	DRS	78	0.554	1.000	III	V	IRS	118	1.000	1.000	V	V	ES1
39	0.755	0.845	IV	IV	DRS	79	0.846	1.000	IV	V	IRS	119	1.000	1.000	V	V	ES1
40	0.715	0.798	III	IV	IRS	80	0.538	1.000	III	V	IRS	120	0.769	1.000	IV	V	IRS
												Mean	0.712	0.853	III	IV	IRS

Source: Primary data analysed (2020).

Note: I, II, III, IV, and V show efficiency categories: very low, low, moderate, high, and optimal (see Table 1). CRS = Constant Return to Scale; VRS = Variable Return to Scale; ES1 = Efficiency Scale=1; IRS = Increasing Return to Scale; DRS = Decreasing Return to Scale.

Table 4. The marketing efficiency level of the patchouli oil industry in Aceh, Indonesia

DMU	Efficiency Level		Category		DMU	Efficiency Level		Category		DMU	Efficiency Level		Category	
	CRS	VRS	CRS	VRS		CRS	VRS	CRS	VRS		CRS	VRS	CRS	VRS
1	0.353	0.353	II	II	41	0.596	0.596	III	III	81	0.578	0.578	III	III
2	0.228	0.228	I	I	42	0.712	0.712	III	III	82	0.314	0.314	II	II
3	0.436	0.436	II	II	43	0.321	0.321	II	II	83	0.184	0.184	I	I
4	0.148	0.148	I	I	44	0.370	0.370	II	II	84	0.263	0.263	II	II
5	0.214	0.214	I	I	45	1.000	1.000	V	V	85	0.181	0.181	I	I
6	0.364	0.364	II	II	46	0.636	0.636	III	III	86	0.093	0.093	I	I
7	0.099	0.099	I	I	47	0.129	0.129	I	I	87	0.474	0.474	II	II
8	0.143	0.143	I	I	48	0.100	0.100	I	I	88	0.483	0.483	II	II
9	0.185	0.185	I	I	49	0.332	0.332	II	II	89	0.270	0.270	II	II
10	0.271	0.271	II	II	50	0.238	0.238	I	I	90	0.374	0.374	II	II
11	0.271	0.271	II	II	51	0.162	0.162	I	I	91	0.169	0.169	I	I
12	0.149	0.149	I	I	52	0.323	0.323	II	II	92	0.173	0.173	I	I
13	0.271	0.271	II	II	53	0.305	0.305	II	II	93	0.385	0.385	II	II
14	0.271	0.271	II	II	54	0.476	0.476	II	II	94	0.168	0.168	I	I
15	0.221	0.221	II	I	55	0.131	0.131	I	II	95	0.189	0.189	I	I
16	1.000	1.000	V	V	56	0.119	0.119	I	I	96	0.169	0.169	I	I
17	1.000	1.000	V	V	57	0.145	0.145	I	I	97	0.189	0.189	I	I
18	0.180	0.180	I	I	58	0.476	0.476	II	II	98	0.189	0.189	I	I
19	0.317	0.317	II	II	59	0.476	0.476	II	II	99	0.517	0.517	III	III
20	0.581	0.581	III	II	60	0.190	0.190	I	I	100	0.470	0.470	II	II
21	0.400	0.400	II	II	61	0.365	0.365	II	II	101	0.514	0.514	III	III
22	0.559	0.559	II	II	62	0.211	0.211	I	I	102	0.497	0.497	II	II
23	0.302	0.302	II	II	63	0.322	0.322	II	II	103	0.470	0.470	II	II
24	0.372	0.372	II	II	64	0.416	0.416	II	II	104	0.444	0.444	II	II
25	0.149	0.149	I	I	65	0.170	0.170	I	I	105	0.470	0.470	II	II
26	0.197	0.197	I	I	66	0.171	0.171	I	I	106	0.235	0.235	I	I
27	0.467	0.467	II	II	67	0.365	0.365	II	II	107	0.471	0.471	II	II
28	0.391	0.391	II	II	68	0.198	0.198	I	I	108	0.236	0.236	I	I
29	0.374	0.374	II	II	69	0.188	0.188	I	I	109	0.477	0.477	II	II
30	0.324	0.324	II	II	70	0.388	0.388	II	II	110	0.424	0.424	II	II
31	0.457	0.457	II	II	71	0.238	0.238	I	I	111	0.198	0.198	I	I
32	0.464	0.464	II	II	72	0.105	0.105	I	I	112	0.378	0.378	II	II
33	0.186	0.186	I	I	73	0.142	0.142	I	I	113	0.457	0.457	II	II
34	0.196	0.196	I	I	74	0.315	0.315	II	II	114	0.216	0.216	I	I
35	0.994	1.000	IV	V	75	0.343	0.343	II	II	115	0.174	0.174	I	I
36	0.479	0.479	II	II	76	0.255	0.255	II	II	116	0.208	0.208	I	I
37	0.864	0.864	IV	IV	77	0.371	0.381	II	II	117	0.460	0.460	II	II
38	0.464	0.464	II	II	78	0.145	0.145	I	I	118	0.459	0.459	II	II
39	0.479	0.479	II	II	79	0.216	0.216	I	I	119	0.311	0.311	II	II
40	0.284	0.284	II	II	80	0.142	0.142	I	I	120	0.240	0.240	I	I
										Mean	0.338	0.338	II	II

Source: Primary data analysed (2020).

Note: I, II, III, IV, and V show efficiency categories: very low, low, moderate, high, and optimal (see Table 1). CRS = Constant Return to Scale; VRS = Variable Return to Scale; ES1 = Efficiency Scale=1; IRS = Increasing Return to Scale; DRS = Decreasing Return to Scale.