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RESEARCH ARTICLE

Assessing technical efficiency in Malaysian pineapple farms: A stochastic frontier analysis approach

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ABSTRACT

Pineapple cultivation proves to be a significant component of Malaysia's agricultural sector. This research was aimed at quantifying technical efficiency of Johor small-scale pineapple agriculturists. Stochastic Frontier Analysis (SFA), a statistical method used to estimate production or cost frontiers, was the preferred method for this purpose. This approach was also used to identify key elements, such as socio-economic characteristics, that influence technical implementation in pineapple farms. A total of 290 pineapple growers participated in the study, and data was collected between 2019 and 2021 during the growing season. The mean observed score of 0.681 is an indication of agriculturists non- maximum efficiency operation activity. However, the inefficiency model showed that aspects such as agricultural experience, extension visits, and participation in workshops significantly reduced inefficiency. The main problem in production points to suboptimal farming applications: agriculturists abstain from using all available agricultural inputs to achieve maximum production. The findings of the study emphasise the need for agriculturists' proficiency refinement and upskilling in pineapple cultivation agrarian andragogy.

Keywords: Stochastic frontier analysis; Technical efficiency

INTRODUCTION

Pineapples are native to tropical South America and are believed to have been brought to Malaysia by the Portuguese in the 16th century (Malaysian Pineapple Industry Board, 1988). In 1888, Europeans began canning pineapples in Singapore. This canning business caught the interest of the Singaporean Chinese, who in 1895 began to commercially operate the store's pineapple canning business.

The pineapple industry is the oldest agricultural industry in Malaysia since commercial canning of pineapples began in 1888 (Malaysian Pineapple Industry Board, 1988). Before the Second World War, in 1941, there was a huge growth of this crop, after which the pineapple industry became a secondary crop.

The pineapple industry plays a crucial role in Malaysia's edible agricultural-based product trade. Malaysia has a competitive advantage in the worldwide market due to its more than a century of experience in the pineapple business. The Malaysian Pineapple Industry Board (MPIB) and the Ministry of Agriculture and Food Industry (MAFI) created a number of strategies and structures to strengthen Malaysia's pineapple business across all stages of value creation, making the agriculture sector increasingly efficient and profitable.

The Malaysian Pineapple Industry Board (MPIB), a board within MAFI formed in 1957 under the Pineapple Industry Ordinance 1957, manages and coordinates Malaysia's pineapple business production. In 1990, the *Pineapple Industry Ordinance 1957* was repealed and replaced by the *Malaysian Pineapple Industry Act 1957 (Revised 1990).*

Pineapples were grown among young rubber trees and in their fields, in Malaya. Pineapple farming has developed significantly in Johor Barat since 1921, along with the growth of the rubber industry. The rubber industry grew slowly in 1931, affecting the growing of pineapple. This

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has raised increased attention to pineapple, a valuable fruit grown on a plantation, because of its contribution to the economy.

The role of pineapple in the Malaysian economy is not limited to food supply, since production offers agriculturists an essential form of income and fresh career possibilities (Dardak, 2017). Throughout the year 2020, the pineapple growing area was approximately 15,849.77 hectares. 75.5% (11,968.80 hectares) in the Peninsular, Sabah 6.4% (1,021.90 hectares) and Sarawak 18.0% (2,859.07 hectares) (Malaysian Pineapple Industry Board, 2019).

According to Table 1.1, Johor boasts the largest allocated area; 8,554.14 hectares, accounting for 54% total acreage (15,849.77 hectares) for year 2020. Other states are Sarawak (18%), Sabah (6.5%), Kedah (5.4%), Pahang (4.3%), Selangor (4%), Perak (2%), Kelantan (1.8%), Terengganu (1.3%), Negeri Sembilan (0.72%), Melaka (0.3%), and Perlis (0.4%).

The provided visual representation, depicted in Figure 1.1, highlights the cultivated land extent as well as the subsequent pineapple output within Malaysia. The aforementioned table illustrates that the nation underwent a variable pattern regarding the land area utilised for cultivation. This shifting tendency exhibits an adverse impact on both the yield and the volume of output. Although the nation experienced a period of relative stagnation between 2006 and 2011, it initiated a resurgence in 2012, demonstrating gradual growth until 2018 before exhibiting a progressive decline until 2020.

The period spanning from 1997 to 2018, as depicted in Figure 1.1, witnessed significant fluctuations in the crop area and production of the country. However, as mentioned and discussed earlier, a certain degree of fluctuation is evident, as seen in the years 2000, 2006, and 2016, during which there was a notable increase in production levels. In recent years, there has been a rise in pineapple production, leading to an increase in pineapple yields. The intervention of the Malaysian government through the Malaysian Pineapple Industry Board (MPIB) has contributed to an augmented pineapple yields compared to the rates observed in conventionally planted areas.

Table 1.1: Allocation of pineapple growing area in hectares in 2020

State	2020 (ha)	%
Johor	8,554.14	53.97
Sarawak	2,859.07	18.04
Pahang	677.22	4.27
Sabah	1,021.90	6.45
Kedah	852.24	5.38
Selangor	621.97	3.92
Pulau Pinang	288.53	1.82
Perak	314.59	1.98
Kelantan	280.86	1.77
Negeri Sembilan	113.69	0.72
Terengganu	204.90	1.29
Melaka	53.74	0.34
Perlis	6.92	0.04
Total	15,849.77	100.00

Source: (Malaysian Pineapple Industry Board, 2021)

The pineapple harvest from 2000 to 2020 showed a fluctuating trend, as shown in Figure 1.2. This was due to factors that the government has emphasised through other policies set out in the government's mandate under the Malaysian Plans. The Eighth Malaysia Plan (RMKe-8, 2001–2005), Ninth Malaysia Plan (RMKe-9, 2006–2010), Eleventh Malaysia Plan (RMKe-11, 2011–2015), and Twelfth Malaysia Plan (RMKe-12, 2016–2020) each place emphasis on different agricultural output (Economic Planning Department, 1980, 1986, 1991, 1996, 2001). Yields from 2016 to 2020 has seen a consistent and substantial decrease, as indicated in Figure 1.2.

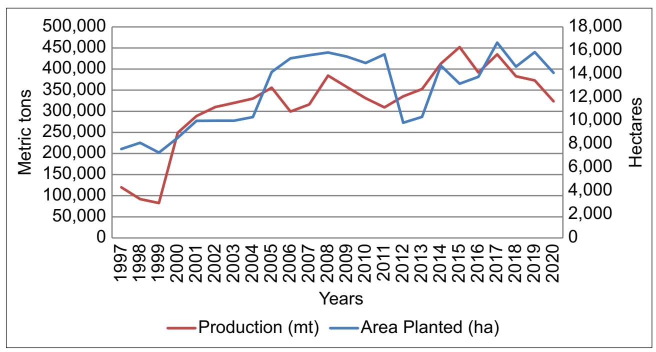

Fig 1.1. Production (tons) and harvest region (hectares) (Malaysia, 1997 - 2020)
Source: (MPIB Yearly Reports, 2010-2021)

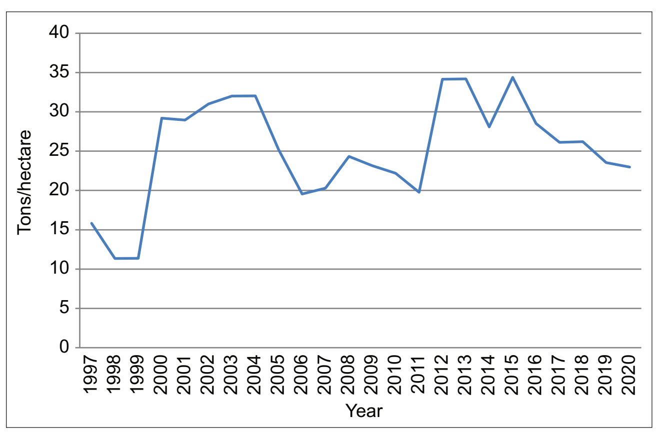

Fig 1.2. Pineapple Yield (1997 to 2020)
Source: (MPIB Yearly Reports, 2010-2021)

Problem statement

Pineapples are a conventional commodity as well as an avenue for revenue for about 1,800 Malaysians and 900 residents of Johor. The area under pineapple cultivation is approximately 7,610 hectares (Malaysian Pineapple Industry Board, 2021). High agricultural production is essential to ensuring that pineapple remains one of the most competitive sources of income for small-scale agriculturists. As a result, it is very important to expand the pineapple sector, especially agricultural production.

In the context of crop production, achieving high yields is imperative, given the potential for agriculturists to realise enhanced sales revenue. Nevertheless, it is essential that high yields correspond with the minimization of quantity, as this will facilitate agriculturists in attaining high productivity and profits in the area of crop production.

Global demand for fresh pineapples has grown significantly in recent years. Global pineapple production is expected to increase by 1.9% per year, and by 2028 it will reach 31 million tonnes (Food and Agriculture Organisation of the United Nations, 2020). The burgeoning demand for fresh pineapples has created an imperative for a strategic initiative to enhance pineapple production in Malaysia. The inability of small-scale pineapple producers in Malaysia to meet the substantial demand for their product has been a recurring issue. The annual report of the Malaysian Pineapple Industry Board (MPIB) underscored impacts from inefficient farm management by the small-scales on production efficiency, resulting in fluctuating pineapple production (Malaysian Pineapple Industry Board, 2020a).

Despite being Malaysia's leading pineapple producer, the average yield in the state of Johor in 2020 amounted to only 22.9 mt/ha, the highest in the country. However, this is still lower than the potential yield of 40–56 mt/ha reported by MPIB (2014b), Rahim & Othman (2019), and Tahiruddin (2019), and yields continue to vary.

Yields are likely to continue to decline due to poor resource utilisation by pineapple growers, traditional cultivation practices with low yields per hectare, flooding, and soil fertility degradation (Hosnan, 2017; Lin & Rahman, 2010). The lack of access to credit hinders the effectiveness of small-scale agriculturists, who comprise a majority of the agricultural workforce and utilise inefficient farming techniques.

Considerable resources have been allocated by the government and various stakeholders towards the research and development of inputs for the enhancement of pineapple production. Currently, the government provides support to agriculturists through the Pineapple Plantation Supplemental Project, offering an input subsidy of 900 kg/acre of compound fertiliser, valued at RM 2,200 per season, or pineapple planting materials in the form of 15,000 suckers per acre, costing RM 2,250. Furthermore, the government is implementing a pineapple cultivation project targeting the high-end market. Under this project, agriculturists will receive subsidies for planting materials at a rate of 20,000 suckers per acre. The findings suggest that the current initiatives are lacking in efficacy, as the level of pineapple production is inadequate for global export marketplace (Malaysian Pineapple Industry Council, 2020b).

The importance of the pineapple industry to Malaysia's agricultural sector and overall economic development has been recognised over the years. Malaysia's high pineapple export potential has strengthened its position as a major pineapple producer globally. As a major pineapple producer globally, Malaysia has to maximise its potential in the pineapple industry potential to strengthen its domestic market and increase revenue from export markets. Despite the existence of market potential for domestic consumption, the most promising opportunity appears to be in the promotion of fruit exports. This finding demonstrates the significant contribution of small-scale pineapple agriculturists to the overall pineapple industry. The role of these agriculturists in contributing to the development of the pineapple industry as a lucrative trade is evident in its high market value, both in domestic and international markets. Although the pineapple sector has grown both in domestic and export markets, its production has also declined by 26% in recent years, from 2017 to 2020 (MPIB, 2020; 2019a). This signifies a decrease in Malaysia's presence in the global pineapple industry, thereby reducing its competitive advantage. A decrease in production can be attributed to several factors and indicates potential production problems.

In recent decades, pineapple cultivation has attracted investment from agriculturists for both domestic consumption and the export market. The state of Johor, which has a favourable environment for pineapple cultivation, makes it a pressure zone that attracts a constant stream of programmes and policies implemented in the past, resulting in a stable production trend for decades. This income opportunity has helped improve the standard of living for agriculturists for generations. small-scale agriculturists often face unpredictable and uncertain outcomes, especially in developing countries (Amuakwa-Mensah et al., 2018; Kaka et al., 2020; Kara et al., 2019; Mishra et al., 2019). In addition to variables beyond agriculturists' control, such as input and product pricing, other variables can be regulated. This includes changing the rate at which inputs are used (such as seeds, fertilisers, herbicides, and pesticides).

As a result, it is important for agriculturists to have a thorough understanding of how to efficiently handle agricultural resources and minimise unnecessary waste. agriculturists can increase their agricultural technical efficiency by maximising production through the optimal use of raw materials and current technologies at the highest possible level. The socio-economic, demographic, and geographic traits of agriculturists also play a role in influencing this phenomenon (TFNet, 2019). Furthermore, agriculturists can acquire the knowledge and skills necessary to adopt modern farming techniques and best practices with the assistance of extension agents, despite having received traditional farming knowledge from their parents or gained expertise through practical experiences. The factors under consideration could potentially impact a farmer's decision-making process regarding pineapple farming practices and the efficient utilisation of inputs, thereby emphasising the differentiation between effective and ineffective farm management strategies.

Currently, there is a scarcity of comprehensive understanding regarding the cultivation of pineapples in Johor using a parametric approach. In order to expand pineapple production in Malaysia, it is imperative to employ a pragmatic approach and assess the comparative efficiencies of resource utilisation among small-scale pineapple cultivators.

Theoretical considerations suggest that increasing pineapple production output could be achieved through a variety of means, including improving yield per unit area, maximizing input utilization, particularly through land expansion, increasing efficiency in asset utilization, and implementing technological advancements derived from innovative approaches. Due to Malaysia's persistent population pressure and fiscal constraints, the practical utility of land extension as a method for expanding production is limited. Hence, the nation is confronted with the choice of enhancing agriculturists' capabilities through the implementation of improved innovations, either by improving their living conditions or by removing existing institutional, market, and financial constraints.

The aforementioned traits suggest that challenges in the production increase may stem from ineffective utilisation of inputs within pineapple agricultural operations. Therefore, considering these challenges, it is imperative to assess pineapple farms technical efficiency. In light of this circumstance, this research intends to assess and model the technical efficiency to facilitate the development of strategies aimed at enhancing efficiency, thereby maximising the utilisation of resources and increasing pineapple production. As pineapple is a major and significant commodity for pineapple agriculturists in Johor, identifying the activities of small-scale pineapple agriculturists is imperative. Therefore, the primary aim of this research was to assess the technical efficiency among pineapple agriculturists in Johor, Malaysia, using Stochastic Frontier Analysis (SFA). Stochastic Frontier Analysis (SFA) is a statistical method used to simultaneously estimates the technical inefficiency factors and the production frontier. This research is intended to identify critical aspects affecting technical efficiency and areas for development to increase the efficiency of pineapple growers.

The results of this study will assist pineapple producers in increasing income, yield, and resource efficiency. This will benefit agriculture and the country as a whole. Therefore, the basis of the study will be the efficiency of the pineapple sector. The notion of increase in pineapple trade income escalation results the growth of monetary value generated by the export of the commodity. The assessment of technical efficiency will elucidate the extent to which the present technology employed in the production process is utilised, as well as the scope for further development. The estimation of input element productivities in relation to pineapple output offers valuable insights into the connections between various input factors and output levels. The scale elasticity of production, as estimated, indicates the sensitivity of output to changes in factor inputs when they are all varied proportionally in the long term. These estimations aid policymakers in identifying the most effective combination of inputs that will lead to increased productivity.

MATERIALS AND METHODS

Data collection

Data gathered was over a period of two years, from 2019 to 2021. Johor districts in Malaysia, such as Muar, Batu Pahat, Pontian, Kluang, Kota Tinggi, and Johor Bahru, are particularly significant in the production of pineapples. A stratified proportional random sampling method was used to select the sample, taking into account the number of registered pineapple growers with the Malaysian Pineapple Industry Board (MPIB) to determine the number of respondents. A total of 329 questionnaires were disseminated, and following data cleaning procedures, 290 were deemed suitable for analysis. The sample under consideration consisted of 32.3% of the population considered representative. According to Cochran et al. (1977), a sample of at least 270 respondents represented a populace of 899 pineapple agriculturists in Johor.

Stochastic frontier model

Stochastic frontier analysis (SFA) is a parametric econometric methodology that computes efficiency. SFA has been proposed by individual authors: Meeusen, van den Broek, and Aigner et al., both in 1977. This method uses maximum likelihood estimation to approximate variables in a production frontier model, which takes into account stochastic variability and technical inefficiencies. SFA distinguishes between these two forms of error, making it a more practical approach than deterministic boundary models (Aigner et al., 1977).

Empirical model estimation

To estimate the technical efficiency of pineapple farms, a cross-log stochastic production function model was employed. This functional form provides some flexibility in defining the relationship between inputs and outputs. Previous studies such as Khai and Yabe (2011), Ahmadu and Alufohai (2012), and K. Rahman et al. (2012) used the Cobb-Douglas functional form, assuming constant output elasticity and unitary input substitution elasticity. The translog functional form used by researchers such as Kouser and Mushtaq (2007), Ogundari and Aklnbogun (2010), Onumah and Acquah (2010), and Donkoh (2013) offers a less restrictive approach to including quadratics. and terms between different products to improve proper fit.

In this study, the trans-log stochastic production function model is defined as follows:

This research employed trans-log stochastic production function model as follows:

$$y_i = \alpha_0 + \sum_{i=1}^{5} \alpha_i + \varepsilon_j$$

$$\ln P_j = \alpha_0 + \sum_{i=1}^{5} \alpha_i + \ln x_i + 0.5 \sum_{j=1}^{5} \alpha_{ii} \ln x_i^2 + \sum_{i=1}^{5} \alpha_{ik} \ln x_i \ln x_k + \varepsilon_j \qquad 1.1$$

Where the stochastic disturbance term, sj, is presented as:

$$\varepsilon_j = g(x;\psi)v_i - h(x;w)u_i \qquad 1.2$$

$g(x;\psi)v_i$ is the random variable function component that cannot be controlled, such as pest and disease attack and weather and it is independently and identically distributed, while $h(x;w)u_i$ is the technical inefficiency function component and it is half-normal distribution, p_j is the quantity of pineapple produced by j-th farmer measured in kg/ac, x_1 is quantity of suckers used measured in kg/ac, x_2 is quantity of fertiliser used measured in kg/ac, x_3 is quantity of agrochemical used measured in lt/ac and x_4 is labour used measured in man days/ha, j is j-th farmer where j = 1, 2, 3..., 290 and i is i-th input where i = 1, 2..., 5 and α_0, α_i, α_{ii} and α_{ik} are the estimated parameters of production technology.

The variables influencing inefficiency in this study are classified into demographic and institutional. The demographic factors comprise of Age (w_1) measured in years, education (w_2) measured as a dummy variable, 1 is assigned to producers with education and 0 to agriculturists who has no education, household size (w_3) measured as the number of people living in the household, farming experience (w_4) measured in years as period of time farmer engaged in pineapple farming, off-farm activities (w_5) measured as a dummy variable where 1 is assigned to agriculturists who had off-farm activities and 0 to full time farm activities. Accordingly, the institutional variables are: extension contact (w_6) measured as dummy variable 1 assigned to agriculturists who had interaction with extension agent, membership of agriculturists association (w_7) measured as dummy variable where 1 assigned to agriculturists who participated and joined pineapple agriculturists/small-scales association and 0 as not joining agriculturists association; and seminar (w_8) as dummy variable where for agriculturists that attend seminar, course or workshop as 1 and otherwise 0 is assigned to the farmer. These two are measured as a binary variable to capture the effect of extension visits and seminars on the inefficiency of farmer.

RESULTS AND DISCUSSION

a. Summary statistics

Agriculturists were, on average, 50 years old on average, with 7.7 years of farming experience (Table 1.2). Agriculturists contacted extension agents an average of six times during the crop cycle. The majority of the agriculturists (185) joined agriculturists' associations, while permanent pineapple growers (165) and another 265 took pineapple farm management courses. Non-formal education, primary school, high school, university, and postgraduate study programmes are the different levels of education. On average, 50% of agriculturists have secondary education.

Table 1.3. displays summary data for the variables used in the efficiency analysis. The average pineapple yield was 18.6 tonne/ac, while the average yield of cultivators, fertilisers, labour, agrochemicals, and hormones was 14,739 suckers/ac, 1,522.2 kg/ac, 55.8 man-days/ac, 11.1 l/ac, and 5.25 l/ac.

Stochastic frontier estimation

The variance parameters for the Cobb-Douglas stochastic production function were 0.0765 and 0.5049, and the T-ratio values were significant at the 1% significance level. This shows that 50.49% of the variation in the yield pattern of pineapple agriculturists was due to differences in their

Table 1.2: Summary statistics for demographic variables of small-scales

Parameters	Frequency (n)	Percentage (%)
Age Group (years)		
<29	26	9.0
30-39	54	18.6
40-49	47	16.2
50-59	76	26.2
60-69	71	24.4
70-79	12	4.1
>80	4	1.3
Gender		
Male	282	97.2
Female	8	2.8
Ethnicity		
Malay	282	97.2
Chinese	8	2.8
Level of Education		
Not Formal	11	3.8
Primary	30	10.3
Secondary	145	50.0
College/University	98	33.8
Postgraduate	6	2.0
Household Size		
1 – 2	51	17.6
3 – 5	149	51.4
6 – 8	81	28.0
9 and above	9	3.1
Farming Experience		
4-7 years	87	30.0
8-11 years	79	27.3
More than 11 years	44	15.2
Occupation		
Main occupation pineapple farmer	165	56.9
Occupation pineapple & other agriculture	40	13.8
Occupation pineapple & non agriculture	80	27.6
Occupation pineapple, other agriculture & non agriculture	5	1.8
Occupation Characteristics of Pineapple agriculturists		
On Pineapple Farm	165	57.6
Off Pineapple farm	125	42.4
Off Pineapple Farm job, consist of		
Oil Palm & Rubber	28	22.4
Animal Farming	5	4.0
Fruit & Vegetable Farming	2	1.6
Fruit Vendor	7	5.6
Machinery Contractors	5	4.0
General contractors	16	12.8
Fruit Stalls	15	12.0
Food Stalls	14	11.2
Other type of business/shop	9	7.2
Civil Servant	9	7.2
Private Sector Employee	15	12
Membership of Pineapple Association		
Member	185	63.7
Not a member	105	36.3
No. of Extension Visit per cycle		
≥7 times	123	42.4
4-6 times	125	43.1
3-4 times	17	5.8
1-2 times	20	6.9
Never been visited	5	1.7
Attended Seminar	265	91.4

technical inefficiency in the use of inputs. MLE for the variables including suckers, fertiliser, agrochemicals, labour, and hormones were found to be 2.016, -5.266, 1.968, 0.302, and 1.579. It was observed that only the variable of labour showed statistical significance. This implies that a marginal increase of 1% in inputs would yield corresponding incremental changes in output of 2.016, -5.266, 1.968, 0.302, and 1.57.

The results of the estimation of coefficients for the translog production function indicate that agrochemicals, suckers², fertilizer², the interaction of sucker and fertiliser, the interaction of fertiliser and agrochemicals and the interaction of agrichemicals and hormone sexhibit positive and statistically significant effects on the pineapple yield. The application of fertiliser was found to have a detrimental and statistically significant impact on the yield of pineapples.

For sucker² and fertiliser², the sucker and fertiliser interactions were significant at 1%, and the interaction term between fertiliser and agricultural chemicals was a significant 5%. Meanwhile, the interaction between fertilisers and agricultural chemicals and hormones was a significant 10%. These findings suggest that there may be a spurious relationship between the use of agrochemicals and hormones on pineapple farms.

The findings of this study also demonstrate that the translog production function exhibits greater flexibility than the Cobb-Douglas production function in explicating the association between input and output. An analysis of elasticity can be utilised to quantify the relationship between input and output (Sharma & Leung, 1998). Table 1.4 presents the elasticity values of individual inputs as well as the total output elasticity. The study determined the elasticities of various inputs in the agricultural production process. Specifically, the elasticities of suckers, fertiliser, agrochemicals, labour, and hormone were found to be

Table 1.3: Output and input variable summary statistics for mean and function analysis

Variable	Unit	Mean	Minimum	Maximum	Std. Dev.
Output					
Fresh pineapples	ton/ac	18.6	10.8	33.0	3.83
Inputs					
Land	Ac	2.3	1	11	1.4
Suckers	No/ac	14,739	10,000	18,500	1,421.4
Fertilizer	Kg/ac	754.1	450	1050	109.8
Labour	Man day/ac	55.8	35	75	11.7
Agrochemicals	l/ac	11.1	5	25	4.1
Hormones	l/ac	5.25	2.7	7	0.85

0.916, 0.106, 2.046, 0.0445, and 1.685. The various inputs had a positive impact on the yield of pineapple crop. It is inferred that a 1% increase in all inputs concomitantly would result in a 5.199% escalation in pineapple yield.

Table 1.4: Elasticity of inputs

Variable	Elasticity
Suckers	0.916
Fertilizer	0.106
Agrochemicals	2.046
Labour	0.445
Hormone	1.685
Returns to Scale (RTS)	5.199

Technical efficiency score

The efficiency levels of farms are detailed in Table 1.5. The efficiencies of pineapple farms were observed to range between 0.401 and 0.990, with none of the farms exhibiting complete efficiency. On average, pineapple growers are capable of producing only 68.1% of their total yield using the current technology and inputs at their disposal. The enhanced utilisation of agricultural inputs can potentially result in a 31.9% increase in pineapple production.

Table 1.5: Technical Efficiency Scores

Efficiency Scores	Frequency	Percentage (%)
1.00	0	0.00
>0.91<1	42	12.76
>0.81≤0.90	41	12.46
>0.71≤0.80	49	14.89
>0.61≤0.70	56	17.02
>0.51≤0.60	40	12.15
>0.41≤0.50	62	18.84
>0.31≤0.40	0	0.00
>0.21≤0.30	0	0.00
>0.10≤0.20	0	0.00
Total	290	100
Mean	0.681	
Minimum	0.401	
Maximum	0.990	
Std. Dev.	0.175	

Source: Field survey data (2021)

b. Technical inefficiency model

Unreliability of the Cobb Douglas production function was a determining factor for the present study to employ the stochastic translog production function to approximate the inefficiency model. The efficiency of agriculturists can be elucidated to some extent by the coefficients derived from the calculation of efficiency determinants. The presence of a positive parameter sign indicates the positive impact of explanatory variables on inefficiency in the inefficiency model, and conversely, a negative parameter sign would suggest the opposite effect.

Table 1.6: Technical inefficiency model

Variables	Parameter	Coefficient	t-stat
Constant	δ_0	3.593	0.452
Age	δ_1	0.043	0.573
Education	δ_2	0.003	0.015
Household Size	δ_3	0.110	0.338
Farming Experience	δ_4	-0.736**	-2.171
Off farm activities	δ_5	0.774	0.642
Extension Visit	δ_6	-2.131***	-2.631
Membership	δ_7	-1.205	-0.721
Seminar	δ_8	-3.856***	-2.839

The cultivation background, interaction with agricultural extension services, and attendance at a technical efficiency seminar were all found to exert a significant influence, as depicted in Table 1.6. The acquisition of pineapple farming knowledge and skills was found to be more readily comprehended by individuals with greater experience in the field, as opposed to those with limited expertise. According to Jaji et al. (2018), it was determined that the farming experience had a noteworthy impact at a 5% level of significance.

Regular communication with extension officers throughout each production cycle has a significant influence on operational efficiency. Enhanced engagement with agricultural extension agents, who possess expertise in addressing agriculturists' challenges, holds the potential to facilitate advancements in pineapple farming techniques.

CONCLUSION

The research conducted investigates technological efficiency of Malaysian pineapple farming, focusing specifically on the state of Johor, which is known for its high volume of pineapple production. In this research, the stochastic translog production function was employed to analyse the technical efficiency of 290 small farms based on cross-sectional data gathered during the 2019–2021 growing season. The study results indicate that pineapple agriculturists in Johor demonstrate technical inefficiency due to inadequate farming methods and suboptimal utilisation of existing agricultural resources.

A number of factors were identified as contributing to technical inefficiency. The study identified age, involvement in non-agricultural activities, and attendance at extension programmes as heterogeneous factors affecting technical inefficiency. It is recommended that governmental entities and pertinent agencies, including the regulatory body overseeing the pineapple industry in Malaysia, conduct seminars aimed at educating agriculturists on sound agricultural practices. Furthermore, it has been demonstrated that the increase in extension services to agriculturists leads to a significant reduction in technical inefficiency. It is imperative to undertake initiatives aimed at expanding and improving the accessibility of extension services to enhance the technical efficiency of agriculturists.

Moreover, it was determined that practical agricultural knowledge is associated with a reduction in technical inefficiency. Therefore, it is imperative to formulate strategies in order to enhance the sharing and dissemination of effective farming techniques among skilled pineapple agriculturists in the designated research region.

Although this study focuses on pineapple production in Johor, it is important to recognise that other regions or states may have different cultural, socio-demographic, environmental, and agricultural practices. Therefore, further research using both static and dynamic panel data, taking into account annual fluctuations in agricultural production and input and related prices is needed to fully understand the technical efficiency of pineapple productivity.

In conclusion, the findings of this study underscore the necessity of implementing interventions aimed at mitigating technical inefficiencies within the pineapple farming sector. Enhancing the knowledge of small-scale pineapple producers can be achieved through educational seminars, expanded ingress to extension services, and facilitation in knowledge sharing among experienced agriculturists. This approach has the potential to improve technical efficiency and subsequently elevate productivity and livelihoods within this agricultural sector.

Author contributions

Conceptualization, M.N.S., N.H.K., N.M.N., J.L., and M.Z.M.; Data curation, M.Z.M.; Formal analysis, M.Z.M.; Investigation, M.Z.M.; Methodology, M.N.S. and M.Z.M.; Project administration, M.N.S., N.H.K., N.M.N., and J.L.; Resources, J.L.; Supervision, M.N.S., N.H.K., N.M.N., and J.L.; Validation, M.N.S., N.H.K., N.M.N., and J.L.; Writing—original draft, M.Z.M.; Writing—review and editing, M.Z.M

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