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DOES OIL PALM CROP AGE MAKE TECHNICAL EFFICIENCY DIFFERENCE AMONG SMALLHOLDERS IN PENINSULAR MALAYSIA?

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Abstract

This study assessed technical efficiency among oil palm smallholders according to crop age categories in the State of Johor, Peninsular Malaysia using descriptive statistics, data envelopment analysis (DEA), analysis of variance (ANOVA) and Tobit regression model. Primary data was collected from 450 oil palm smallholders through survey using multi-stage sampling. The mean technical efficiency based on VRS assumption for smallholders under <9 years, 9-18years and 19years and above crop age categories were 0.9388, 0.8584 and 0.9851, respectively. The result of ANOVA shows significant difference in technical efficiency existed among the oil palm smallholders under <9 years, 9-18years and 19years and above crop age *categories at 1%. The finding also indicates that extension contact, household size, age of farmer, access to credit facilities, soil conservation practices, oil palm income, experience, educational level, off-farm income, membership of smallholder organization and government intervention among others influence technical inefficiency of the smallholders. We recommend policies such as increasing oil palm smallholder's farm sizes to enhance their technical efficiencies. There is need to re-strategies the extension program for effective monitoring and supervision of the smallholders' to ensure that they comply with recommended inputs use.*

Keywords: Oil palm crop age, Technical efficiency, Smallholders, Peninsular Malaysia, DEA, ANOVA

INTRODUCTION

Malaysia has been the world's second – largest producer of palm oil, and is a major exporter of palm oil to Europe. The demand for palm oil kept increasing due to continuous growth in the world's population and certainly, palm oil takes leading position as the topmost significant vegetable oil in the world (Choong & McKay, 2014). According to the Oil World Annual (2014), palm oil production during the 2014/2015 was estimated to be 60.2 million tons and it is expected that minimum of 78 million tons of palm oil would be required to meet worldwide demand by 2020 (Mielke, 2013). In 2014, Malaysia alone produced about 19.69 million tons while in 2015 it increased to 20.260 million tons (MPOB, 2015). Oil palm industry contributes larger proportion to the Malaysia's national economy and play vital role in poverty eradication and directly provided job to over 610,000 persons, with more than 177,000 oil palm smallholders in the country (Economic Transformation Programme ETP, 2012). In 2014, the Malaysian palm oil industry's size of exports recorded a drop, though there was high returns due to mainly high price. ''The palm oil exports and derived products cut down to 25.1 million tons or by 2.5 percent from 25.7 million tons year-on-year. But earnings from palm oil increased by 3.7 percent to RM63.6 billion from RM61.4 billion in 2013 '' (MPOB, 2014). While the mean crude palm oil price went up by a small increase of 0.5 percent over the relative periods.

Malaysia had around 5.23 million hectares of oil palm planted areas in 2013. The States with the largest smallholders oil palm planted areas were Johor with 125,459.83 hectares (about 39.10 percent), followed by Perak with 53,089.78 hectares (16.55%) in the Peninsular Malaysia (MPOB, 2001). ''The oil palm industry was largely subjugated by big plantation companies generally possessed by private stakeholders and government-linked companies which accounted for 62% of the total oil palm area in terms of category of ownership'' (Kamalrudin &

Abdullah, 2014). ''Though, a substantial portion of oil palm area was in the ownership of organized smallholders and independent smallholders, which still accounts for 24 percent and 14 percent of the total area, respectively'' (MPOB, 2014). Oil palm Smallholders constitutes about 40% of Malaysia's oil palm area, are being strongly supported by the government to boost their overall FFB yield. This is part of the task to achieve the 2020 target of raising annual FFB yields to 26.2t/ha as the national average across all categories of ownership, smallholdings and plantations included. Some of the ways to achieve this are to encourage independent smallholders to adopt the best industry practices, and to set up cooperatives of oil palm planters across the country to educate and increase awareness in new improved technologies. Inputs such as fertilizer requirements depends on the age of palms, soil type and field conditions (Kamalrudin & Abdullah, 2014). The palm oil industry in Malaysia has great growth potential in both fresh fruit bunch (FFB) yield and in oil extraction rate. These can be achieved by ensuring that smallholder's utilized production and other farm inputs efficiently. Efficiency in utilization of scarce farm resources by farmers increases their agricultural productivity and the need for sustained empirical studies to assess the extent and sources of inefficiency among smallholder oil palm farm households according to age of crop is a herculean task. Measurement of efficiency in smallholder's oil palm production shows the level of farmers' inputs use and other farming activities.

Smallholders in developing countries encounter difficulties in making use of all the potentials in new farming technologies and other farm resources, rendering them to be inefficient in farm decision making. Earlier studies on oil palm production estimated farm's technical efficiency on aggregated data ignoring crop age profile which results in a biased estimates, since oil palm production cycle according to Ismail & Mamat (2002), can generally be divided into a non-productive phase lasting three years after planting, period of steadily rising yield reaching a peak and a period of declining yield. The last phase of the cycle is associated with increased production costs and declining profit. The yields of oil palm thus varies across crop age. This necessitates disaggregated data technical efficiency analysis of the smallholder's oil palm production according crop age in Peninsular Malaysia. There is death of information on study of technical efficiency of oil palm production according to crop age in Malaysia to the knowledge of the researchers, though a good number of studies on technical efficiency are available. Thus, undertaking study on technical efficiency of the smallholder's oil palm production according to crop age in Peninsular Malaysia is of paramount importance. It was against this backdrop that this study was conceptualized to analyze technical efficiency of smallholder's oil palm production according to crop age in the study area. This study would bridge the gap in existing literature on measurement of relative efficiency and determinants of inefficiency of the oil palm smallholders according to crop age in Peninsula Malaysia using a two-stage Data Envelopment Analysis (DEA) method. It would also help identify smallholders who are more efficient at particular crop age category and also make policy recommendation for the smallholders, decision makers and planners so that the smallholders can either produce more with the present cost structure or produce the current level of oil palm output with minimum cost of production.

The main objective of the study was to estimate technical efficiency of oil palm smallholders according to the age of crop. The specific objectives were to: estimate and compare the level of technical efficiency of oil palm smallholders according to the age of crop; and examine the determinants of technical inefficiency of oil palm smallholders according to the age of crops. The following hypotheses were postulated for testing: there is no significant difference in technical efficiency level of oil palm smallholders according age of crops; and there is significant difference in technical efficiency of oil palm smallholders according age of crops. The paper is organized into section one covering introduction, objectives and hypotheses. Section two described the theoretical framework. Section three discusses the methodology and section four deals with the results and discussion while section five provides the conclusion and policy recommendations.

THEORETICAL FRAMEWORK

Based on the theory of production, there are two main approaches in measuring firm efficiency; a parametric stochastic frontier (SFA) production function and a non-parametric Data envelopment Analysis (DEA) approach. Measurement of efficiency of any organization (hospitals, bank, insurance companies, and firms or farms) that uses multiple inputs and generates multiple outputs is complex and comparisons across units are difficult (Bhat *et. al.,* 2001). ‘’The DEA using linear programming constructs the efficiency frontier with the best performing farms of the sample while the parametric methods rely on specifying a production function and estimating its parameters with econometrics’’ (Selim & Bursalıoğlu, 2015). Farrell (1957) and Charnes *et al.* (1978), initially introduced the DEA which is a mathematical programming approach to the construction of production frontiers and the measurement of efficiency of the constructed frontiers (Barros & Dieke, 2008).

DEA is getting growing prominence as a tool for estimation and improvement of the performance of industrial and service operations. According to Charnes *et al.* (2013), DEA has been widely used in evaluating the performance and benchmarking of schools, hospitals, bank branches, production plants, etc. The relative performance of the oil palm smallholders according to crop age in our research was well-defined as the ratio of the weighted total of its outputs fresh fruits brunches to the weighted total of its farm inputs. Mostly, a DEA production frontier can be operational non-parametric either by input-orientation or output-orientation, under the assumptions of constant returns to scale (CRS) or variable returns to scale (VRS) (Merkert & Hensher, 2011). Charnes, Cooper & Rhodes (1978), suggested the earlier DEA model, which is the model that pin points dissimilarities amongst firms (DMUs) in ultimate approach. Some of the later models particularly that of Banker *et al.* (1984), incorporates some of the reasons to efficiency variances into the models themselves. The BCC model accounts for the result of VRS within the evaluated group of DMUs, while CCR model accounts for the result of CRS (Golany & Roll, 1989). ''The DEA method assume either input or output-orientation, of which the input-orientated approach determines the minimum input for which the observed production of the ith firm is possible, while the output-oriented determines the maximum output of the ith firm given the observed inputs'' (Selim & Bursalıoğlu, 2015; Hoff, 2007). The DEA determines the efficiency of individual oil palm farm's in a group relative to the other oil palm farms or DMUs in the group. The most efficient oil palm farms constitutes the efficient frontier of the group, relative to which the efficiencies of the remaining oil palm farms are measured. Since the DEA frontier, does not require any functional form specification, it takes care of this problem by letting the individual oil palm farm to choose the vectors of the input and output weights, which maximize its own ratio of weighted output to weighted input subject to the constraint that the weight vectors chosen by the ith oil palm farm should not allow any oil palm farm to achieve a ratio of weighted output to weighted input in excess of unity'' (Selim & Bursalıoğlu, 2015). Therefore, each oil palm farm is judged according to standards set by itself (Wang & Huang, 2007). This study applied the input-oriented DEA approach, this is because oil palm smallholders have control over inputs than output.

Data Envelopment Analysis (DEA)

The input-oriented DEA-CRS model used for estimation of oil palm smallholder's technical efficiency (TE) according to crop age as proposed by Charnes, Cooper & Rhodes (1978) is expressed as:

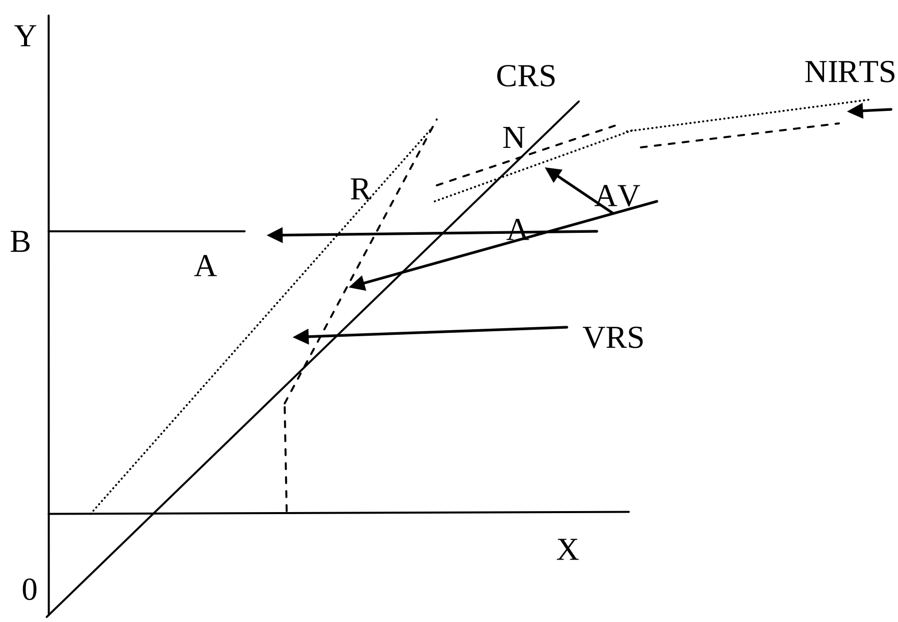
$$\begin{aligned} &\text{Min}_{\theta,\lambda} :\theta \\ &\text{Subject to} - \theta yi + Y\lambda \geq 0, \\ &\qquad \theta xi - X\lambda \geq 0, \\ &\qquad \lambda \geq 0, \end{aligned}$$

Where, θ = ith smallholder oil palm farm's technical efficiency score; yi = output (FFB) of ith smallholder farm, xi = quantity of input used by ith smallholder farm. Assuming N is number of smallholder farm where Y denotes FFB for N oil palm farms, X is input for N oil palm farm, λ is a vector of constants N x 1, and θ is a scalar. The Yλ and Xλ are technical efficiency estimation on the production frontier. The θ denotes technical efficiency score of oil palm farm which ranges between 0 and 1 value. The constraint in DEA-CRS is that, it assumes all DMUs performs at optimum scale therefore measurement of technical efficiency is confounded by scale efficiency (SE). The DEA-VRS is the extension of CRS-DEA model as suggested by Banker, Charnes, & Cooper (1984) and this DEA-VRS model referred to as BCC model. The DEA-VRS is modified from DEA-CRS (CCR) model by adding the convexity constraint N1'λ as shown below:

$$\text{Min}_{\theta,\lambda} : \theta$$
$$\text{Subject to} - \theta y_i + Y\lambda \geq 0,$$
$$\theta x_i - X\lambda \geq 0,$$
$$N1'\lambda = 1$$
$$\lambda \geq 0,$$

Where, N1'= vector of N x 1 and a convexity constraint whereas λ = N x 1 is a vector of intensity variables. The quantities increase in oil palm output with farm input quantities fixed constant is shown as $1 \leq \theta < \infty$ and $\theta - 1$. The modification of DEA-VRS model allows the technical efficiency measurement divided from SE effects. The SE denotes the ratio of the average output of an oil palm smallholder farm operating at the point compared to the average output at the point of operating with technical efficiency.

Figure 1. Scale Efficiency (SE) obtained from technical efficiency of VRS and CRS



Source: Coelli *et al.* (1998) adapted by Rosli *et al.* (2013)

Assuming the smallholder oil palm farm apply single input to produce single output. The smallholder oil palm farm's technical inefficiency of the point A in figure 1 is the distance AAc for assumption under CRS while technical inefficiency for the assumption under VRS is given by AAv. Therefore, variance of Ac and Av is the scale inefficiency. The TE relationship between VRS and CRS is illustrated as:

$TE_{CRS} = \frac{BA_C}{BA}$, $TE_{VRS} = \frac{BA_V}{BA}$ and $SE = \frac{BA_C}{BA_V}$

The SE indicates whether the smallholder oil palm farm is operating at increasing or decreasing returns to scale and non-increasing returns to scale (NIRS) is integrated. The SE can determine when NIRS technical efficiency estimates equals to VRS technical efficiency estimates. Figure 1 shows at Point B, the NIRS is not equal to technical efficiency of VRS, which shows increasing returns to scale while point N indicates that the NIRS is equal to technical efficiency of VRS. This implies that the smallholder oil palm farm is operating at decreasing returns to scale.

Tobit Regression Model

The determinants of oil palm smallholders technical inefficiency according to crop age was estimated using the two-limit Tobit regression model. The two-limit Tobit regression model is appropriate since the efficiency scores vary between 0 and 1(Long, 1997). The Tobit model is more appropriate method of estimation because it produce reliable estimates for the unknown parameters. The estimated DEA efficiency scores are in some way censored since there are usually many scores equal to one (Simar & Wilson, 2007). Several earlier studies regressed the DEA efficiency estimates on quit a number of covariates in the second stage using a censored Tobit regression model (Bhatt & Bhat, 2014; Alam, 2011; Nayagaka *et al.,* 2010; Amornkitvikai & Harvie, 2010; McDonald, 2009; Bravo-Ureta *et al.,* 2007; Coelli *et al*., 2002; Hoff, 2007; Featherstone *et. al.,* 1997; Amemiya, 1981), while others such as Aly *et al.* (1990), Chirkos & Sears (994), Ray (1991), Sexton *et al.* (1994), Stanton (2002) applied an ordinary least squares (OLS) linear regression model to estimate determinants of technical inefficiency in a two stage-DEA approach. The OLS estimates gives ''biased, unreliable and inefficient estimates (Gujarati, 2003), since it underestimates the true effect of the parameters by reducing the slope''. The implicit form of the Tobit regression model is expressed as:

$$y_i^* = \alpha_0 + \sum \alpha_n X_{jn} + \varepsilon_i$$

Where, y_i^* = represents the technical efficiency scores of ith oil palm smallholders farm according to crop age; j is a vector of unknown parameters, X^{jn} is vector of explanatory variables n (n = 1, 2,3,..., k) for farm ith and ε^{i} = an error term that is independently and normally distributed with mean zero and common variance σ^{2}, representing yi as the observed variables,

$$y_i = 0 \quad \text{if} \quad y_i^* \leq 0$$

$$y_i = y_i^* \quad \text{if} \quad 0 < y_i^* < 1$$

$$y_i = 1 \quad \text{if} \quad y_i^* \geq 1$$

The likelihood function is expressed following Maddala (1986) as:

$$L(\alpha, \sigma/y_i, x_i, L_{1i}, L_{2i}) = \underset{yi=L_{1i}}{\eta} \varphi\left(\frac{L_{1i} - \alpha' x_i}{\sigma}\right) \underset{y_i=y_i^*}{\eta} \frac{1}{\sigma} \varphi\left(\frac{y_i - x_i' \alpha}{\sigma}\right) \underset{y_i=L_{2i}}{\eta} \left[\frac{1 - \varphi(L_{2i} - \alpha' x_i)}{\sigma}\right]$$

Where, L_{1j} = 0, lower limit; L_{2j} = 1, upper limit; η (.) and φ (.) = normal standard cumulative and density functions. ''As the log function is monotonically increasing function, it is simpler to work with log of likelihood function rather than likelihood function and the maximum values of these two functions are the same (Greene, 2003)''.

METHODOLOGY

Study Area

The study area ''State of Johor'' is situated between longitude 01^{0} 28'N and latitude 103^{0}46'E of Western Malaysia (Peninsular Malaysia). The State of Johor covered a total area of 18, 986 square kilometers and bordered Pahang to the Northern part, Melaka and Negeri Sembilan to the Northwest and the Strait of Malacca to the West and also South China Sea to the East. It also breezes around the Republic of Singapore's northern border. The capital of Johor is located at Johor Bahru it is the largest city within the State. The main administrative divisions in Johor includes Johor Bahru, Kluang, BatuPahat, Kota Tinggi, Ledang, Kulaijaya, Mersing, Pontian, Muar and Segamat. Johor is inhabited by about 3,385,000 total number of people with Malay race having the largest percentage followed by the Chinese, Indians and other foreign citizens. The State's topography is generally flat and the forest is covered with substantial swamps, though rises in the east-central area to the heights of over 3,000 feet (900 meters) (Encarta, 2007). Major food crops, vegetables and fruits grown in Johor are paddy, cash crop (maize), pawpaw, banana and pineapple, ornamental crops and industrial crops (palm oil). The residents of the State also participate in agricultural activities such as fish farming, general livestock production, milling and palm oil processing. The industries sited in the State includes low land tea industry, handicraft, pottery and electronic industries.

Sources of Data, Method of data collection and Sampling techniques

Primary data was mainly used as the source of data for this study. The data were collected at the farm level from cross section of independent oil palm smallholders through survey with the help of enumerators using structured questionnaire while the secondary sources of information include text books, journals, conference papers and publications from organizations. A multistage sampling procedure was used for this study. In the first stage, the State of Johor in Peninsular Malaysia was purposely selected and we categorized the oil palm smallholders into three groups according to age of their crops i.e. less than 9years of crop age as the first category, 9-18 years of crop age as the second category and those with 19 years and above crop age as the third category. This was because oil palm exhibits three phases in its life cycle and crop yield varies across crop age. That is, non-productive phase lasting three years after planting, period of steadily rising yield reaching a peak and a period of declining yield (Ismail & Mamat, 2002). Johor is the State that has large oil palm planted areas and have large numbers of independent smallholders in the Peninsular Malaysia. In the second stage, oil palm smallholders were stratified randomly according to ten (10) production units. While in the third stage, about 45 oil palm smallholders were randomly selected using simple random sampling technique from each of the production units, giving a total sample size of 450 respondents for the Study.

Analytical Techniques

The analytical tools employed for this study includes descriptive statistics, data envelopment analysis (DEA), analysis of variance (ANOVA) and Tobit regression analysis.

Empirical Model Specification

The choice of input or output-oriented DEA model depends on the quantities of inputs or output the oil palm smallholders have (Coelli, *et al.*, 1998). Since oil palm smallholders have more control over inputs than output, we therefore, employed input-oriented DEA model in this study. The input -oriented DEA model under the assumption of constant returns to scale (CRS) and variable returns to scale (VRS) were used to estimate the overall technical and pure technical efficiencies of the oil palm smallholders according to age of crop in Peninsular Malaysia.

Overall Technical Efficiency

The input oriented constant return to scale (CRS) DEA model for estimating overall technical efficiency is specified following Coelli, *et al*. (1998) as:

$$\text{Min}_{\theta,\lambda}\ \theta$$

Subject to

$$-y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$\lambda \geq 0$$

Where, Y_j = output matrix for N oil palm smallholder farms

θj = overall technical efficiency of the ith oil palm smallholder farm

λj = N x 1 constraints

Xj = input matrix for N oil palm smallholder farms

y_{ij} = output of the ith oil palm smallholder farm in tones

xi = input vector of x_{1ij}, x_{2ij}.......x_{6ij} inputs of the ith oil palm smallholder farm

x_{ij1} = cultivated area in hectares

x_{ij2} = number of oil palm trees

x_{ij3} = amount of fertilizer used in kilogram

x_{ij4} = chemicals used in liters

x_{ij5} = hired labour (man-days)

x_{ij6} = family labour (man-days)

j = 1, 2, palm oil farms according to age of crop

Pure Technical Efficiency

The input-oriented variable return to scale (VRS) DEA model for calculation of pure technical efficiency is expressed (Coelli *et al.*, 1998) as:

$$\text{Min}_{\theta,\lambda}\ \theta,$$

Subject to

$$-y_i + Y\lambda \geq 0$$
$$\theta x_i\ X\lambda \geq 0$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

Where, θ = pure technical efficiency of ith oil palm smallholder farm, $N1'\lambda=1$ is a convexity constraint which ensure that an inefficient farm is only benchmark against farms of similar size.

Scale Efficiency

Scale efficiency was estimated by dividing the overall technical efficiency (TE_{CRS}) by pure technical efficiency (TE_{VRS}). It is expressed as:

$$SE = TE_{CRS} / TE_{VRS}$$

Where, SE = 1, implies scale efficiency (SE) or constant return to scale (CRS)

SE < 1, implies scale inefficiency. The scale inefficiencies arise due to presence of either increasing returns to scale or decreasing return to scale. This was determined by estimating another DEA model under non-increasing returns to scale (NIRS). Following Coelli, *et al.* (1998), input oriented (VRS) DEA model under non increasing returns to scale (NIRS) is expressed as:

$$\text{Min}_{\theta,\lambda}\ \theta,$$

Subject to

$$-y_i + Y\lambda \geq 0$$

$$x_i - X \geq 0$$

$$N1'\lambda \leq 1$$

$$\lambda \geq 0$$

Analysis of Variance (ANOVA)

The analysis of variance (one way ANOVA) was used to test the hypothesis there was no significant difference in the level of technical efficiency among oil palm smallholders according crop to age in the study area.

Tobit Regression Analysis of Determinants of Technical Inefficiency

Technical efficiency scores obtained from the solution of the DEA problem at the first stage after subtracting it from one were then regressed on farm and oil palm smallholders' characteristics, institutional and other determinants that influence technical inefficiency at the second stage using a Tobit regression model. The technical efficiency scores were deducted from one following Ismail (2015), Featherstone *et al.* (1997) and Ogunyinka & Ajibefun (2004). The reduced form of the Tobit regression model stated as:

$\text{Tech ineff}_{ij} = \alpha_0 + \alpha_1 x_{ij1} + \alpha_2 x_{ij2} + \alpha_3 x_{ij3} + \alpha_4 x_{ij4} + \alpha_5 x_{ij5} + \alpha_6 x_{ij6} + \alpha_7 x_{ij7} + \alpha_8 x_{ij8} + \alpha_9 x_{ij9} + \alpha_{10} x_{ij10} + \alpha_{11} x_{ij11} + \alpha_{12} x_{ij12} + \alpha_{13} x_{ij13} + \alpha_{14} x_{ij14} + \alpha_{15} x_{ij15} + \alpha_{16} x_{ij16} + \alpha_{117} x_{ij17} + \alpha_{18} x_{ij18} + \varepsilon_i$

Where, Tech ineff = Technical inefficiency score for ith oil palm smallholder; α_0 = intercept coefficient $\alpha_1 - \alpha_7$ = parameters to be estimated. The socio-economic determinants includes: x_1 = age of a farmer (years), x_2= Age of farmer squared, x_3 = educational level (years spent in formal education), x_4 = household size (number of persons in the household), x_5= experience in farming (years), x_6 = off-farm income (RM) and x_7 = oil palm income in RM. The institutional determinants were: X_8 = government intervention (1subsidies and 0 otherwise), X_9= access to credit facilities (1 if the farmer has access to credit and 0 otherwise), X_{10} = extension contacts (1 if frequent contact with extension agents and 0 otherwise), x_{11} = membership of oil palm smallholders association (1 member, 0 otherwise) and other determinants such as: x_{12}= age of the crop (years), x_{13}= Age of the crop squared, x_{14} = land clearing (1 burning, 0 otherwise), x_{15} =fertilizers use (kg) , x_{16}= pesticides use (number of replications), x_{17} = pests & weed control method (1 biological, 0 otherwise), and x_{18} = soil conservation practices (1 leaving the oil palm fronds to rot and used as mulch, 0 otherwise). The ε = error term, i = 1, 2, 3… N and j = 1, 2, palm oil farms according to age crop.

RESULTS AND DISCUSSION

The result of the study were discussed under, diagnostic statistics of data used for the analyses, technical efficiency of oil palm smallholders, analysis of variance (ANOVA) and determinants of technical inefficiency.

Diagnostic Statistics of Data used for the Analyses According to Crop Age

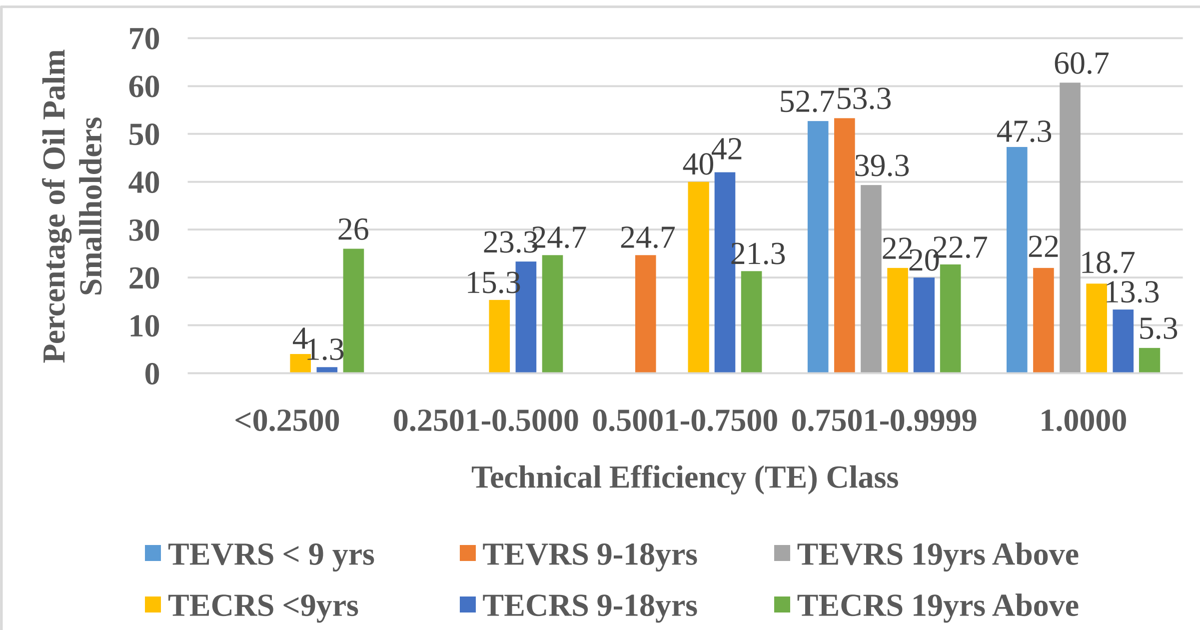
Before the analyses, the data used to estimate technical efficiency as well as the determinants of technical inefficiency of the oil palm smallholder farms were first subjected diagnostic statistics and tested for normality distribution in which we excluded the dummy variables following Iliyasu & Mohamed (2016). The result of Jarque-Bera tests for oil palm smallholders under <9years, 9-18years and 19years & above crop age categories were 0.088745(p-value 0.956598), 1.423080(p-value 0.490888) and 0.145823(p-value 0.929683) respectively. These shows that the residuals were in the area of normal distribution. The result from White and Breusch-Pagan-Godfrey tests for the smallholders under <9years crop age category's F-statistics were 0.635105(p-value 0.8318) and 0.680651 (p-value 0.7900) respectively while White and Breusch-Pagan-Godfrey tests for the smallholders under 9-18years crop age category's F-statistics were 1.081629(p-value 0.3796) and 1.552864(p-value 0.1008) respectively confirms nonexistence of heteroscedasticity. The White and Breusch-Pagan-Godfrey tests for smallholders under 19years & above crop age category's F-statistics were 0.879421 (p-value 0.5824) and 0.836764 (p-value 0.6284) respectively, also suggests absence of heteroscedasticity. The finding of variance inflation factors (VIFs) tests for all the variables were less than ten (<10), these indicates the absences of multicollinearity. The result of Ramsey RESET tests F-statistics for the smallholders under <9years, 9-18years and 19years & above crop age categories were 0.279814 (p-value 0.5977), 0.297333 (p-value 0.5865) and

0.326941(p-value 0.5684) respectively, these also shows that the specification is perfect and the data were well fitted for the analyses.

Technical Efficiency of Oil Palm Smallholders According to Crop Age in Peninsular Malaysia

The technical efficiency of the oil palm smallholders were disaggregated into variable return to scale (VRS), constant return to scale, non-increasing return to scale (NIRTS) and scale efficiency (SE) and estimated under <9years, 9-18years and 19years and above crop age categories. The finding are presented in figure 2, 3, 4 and 5.

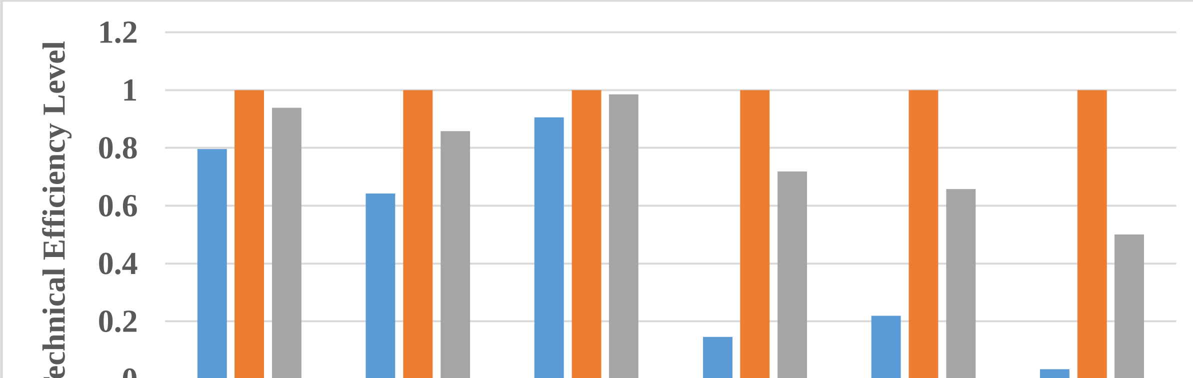
Figure 2: Technical Efficiency of Oil Palm Smallholders According to Crop Age in Peninsular Malaysia



The result in figure 2 & 3 shows the variable returns to scale (VRS) and constant returns to scale (CRS) technical efficiency scores of the oil palm smallholders according to crop age in the study area. The technical efficiency estimates based on VRS assumption shows that smallholders under <9 years and 19years and above crop age operates between 0.7501 and 1.0000 efficiency class with a mean of 0.9388 and 0.9851, respectively. While smallholders under 9-18 years of crop age operates between 0.5001 and 1.0000 with mean of 0.8584. The result further shows that 47.33%, 22.0% and 60.67% of the smallholders under <9years, 9-18years and 19years and above, respectively crop age categories were technically efficient. These suggests that about 52.67%, 78.0% and 39.33% of the oil palm smallholders under

<9years, 9-18years and 19years and above crop age categories respectively, were technically inefficient.

Figure 3: Summary Technical Efficiency of Oil Palm Smallholders According to Crop Age Categories in Peninsular Malaysia

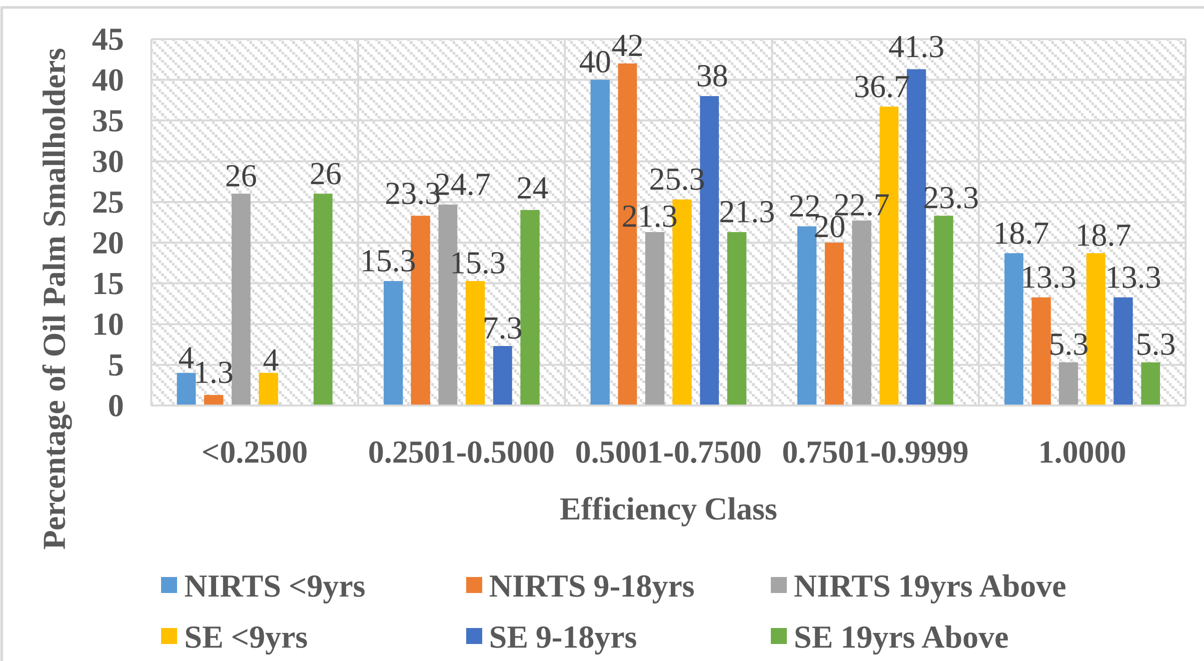


	TEVRS < 9yrs	TEVRS 9-18yrs	TEVRS 19yrs & Above	TECRS <9yrs	TECRS 9-18yrs	TECRS 19yrs & Above
Min	0.7962	0.6416	0.9055	0.146	0.2187	0.0344
Max	1	1	1	1	1	1
Mean	0.9388	0.8584	0.9851	0.7182	0.6579	0.4999

Generally, the mean efficiency values shows that smallholders under <9 years and 19years and above crop age produced oil palm at about 93.88% and 98.51% efficiency levels while those under 9-18years of crop age produce at 85.84% level, implying 6.12%, 1.49% and 14.16% were due to inefficiency of the oil palm smallholders in State of Johor, Peninsula Malaysia. The mean efficiency values suggests that under the current underlying oil palm smallholders' production technology, oil palm farms under <9years, 9-18years and 19years and above age of crop may perhaps reduce the quantity of inputs by 6.12%, 1.49% and 14.16% respectively and continue to produce the same bundle of output. This further suggests that there was merely 6.12%, 1.49% and 14.16% inefficiency levels existing among the oil palm smallholders under <9years, 9-18years and 19years and above crop age categories respectively. Smallholders under 9-18years crop age categories have the lowest prospects of inputs reduction, followed by those under <9years crop age. While smallholders' with 19years and above crop age categories having the highest inputs reducing potentials to enhance oil palm production efficiency. This implies that there was reasonable variation in yield among the oil palm smallholders in the three crop age categories in the study area.

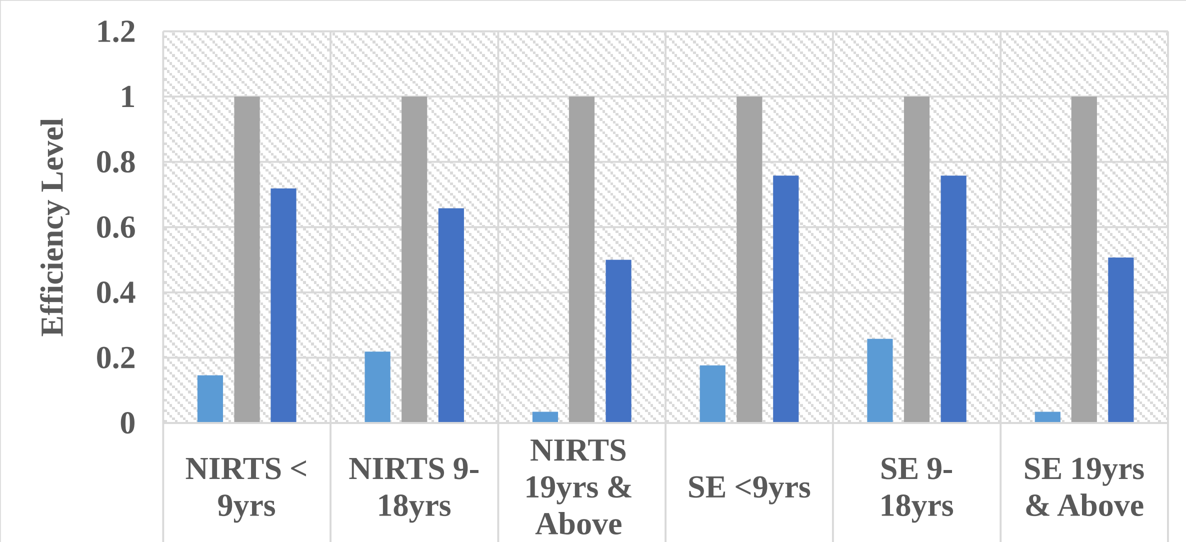
The technical efficiency scores estimated under CRS assumption shows that all the oil palm smallholders under the three crop age categories operate between 0.0000-1.0000 efficiency levels with mean efficiency value of 0.7182, 0.6579 and 0.4999, respectively. The mean CRS efficiency score suggests 71.82%, 65.79% and 49.99% efficiency levels for smallholders under <9years, 9-18years and 19years and above crop age categories respectively with 28.18%, 34.21% and 50.01% inefficiency levels. The implication of low efficiency scores in the CRS hypothesis for all the crop age categories compared to the VRS hypothesis conformed to the theory as the enveloping surface is flexible and tighter in the CRS (Anita *et. al.*, 2013), allowing low efficiency estimates. Similarly, the proportion of oil palm smallholder farms that were fully efficient also reduced from the 47.33%, 22% and 60.67% in all three crop age categories under VRS to 18.67%, 13.33% and 5.33% under the CRS.

Figure 4: Non-Increasing Return to Scale & Scale Efficiency of Oil Palm Smallholders According to Crop Age Categories in Peninsula Malaysia



The result of scale efficiency (SE) 4 & 5 indicates that oil palm smallholders under <9years and 19years and above crop age categories operate between 0.0000-1.0000 efficiency levels with mean efficiency values of 0.7579 and 0.5070, respectively while those under 9-18years crop age category operates between 0.2501- 1.0000 efficiency levels with mean efficiency value of 0.757. These reveals that the mean scale efficiency (SE) scores of the oil palm smallholders in all the crop age categories were higher compared with the mean CRS technical efficiency scores, but lower than the mean VRS technical efficiency scores.

Figure 5: Summary of Non-increasing Return to Scale and Scale Efficiency of Oil Palm Smallholders According to Crop Age Categories in Peninsula



	NIRTS < 9yrs	NIRTS 9-18yrs	NIRTS 19yrs & Above	SE <9yrs	SE 9-18yrs	SE 19yrs & Above
Min	0.146	0.2187	0.0345	0.176	0.2575	0.0344
Max	1	1	1	1	1	1
Mean	0.7182	0.6579	0.4999	0.7579	0.7575	0.507

The lower SE scores in figure 5 compared to VRS technical efficiency scores in figure 2 suggest that apart from constraints in decision-making, scale of production or size of farm holdings seems to results in inefficiency (Padilla-Fernandez & Nuthall, 2012; Gabdo *et al.,* 2014). Increase in the scale of production is an opportunity to improve efficiency in oil palm smallholder's productivity. The result based on SE shows that 122(81.33%), 130(86.67) and 142(94.67) of the oil palm smallholders under <9years, 9-18years and 19years and above crop age categories respectively operates at increasing return to scale of production while 28(18.67), 20(13.33) and 8(5.33) respectively operates at constant return to scale.

Analysis of Variance (ANOVA)

The one way analysis of variance (ANOVA) was carried out to test if there was significance difference in mean technical efficiency of the oil palm smallholders under <9years, 9-18years and 19years and above crop age categories. The findings are presented in table 2.

Table 2: Hypotheses Testing for Difference in mean Technical Efficiency among Oil Palm Smallholders According to Crop Age based on Analysis of Variance (ANOVA)

Hypothesis	Sum of Square	Degree of freedom	Mean Square	F-value	P-value	Decision
Technical Efficiency						
H_0: $_{\text{no sig diff}}$						
Between groups	1.234	2	0.617	95.191	0.0000***	Fail to accept
Within groups	2.897	447	0.006			

***Mean Difference Significant at 1% level

The finding of one way analysis of variance (ANOVA) in table 2 shows that there was significant difference in the mean technical efficiency of the oil palm smallholders under <9years, 9-18years and 19years and above crop age categories at 1% level of significance. We therefore fail to accept the null hypothesis of no significance difference in mean technical efficiency among oil palm smallholders in the study area.

Determinants of Technical Inefficiency in Smallholder's Oil Palm Production

The technical inefficiency scores calculated by subtracting the technical efficiency scores obtained from the solution of the DEA problem at the first stage from one, were regressed on farm and oil palm smallholders' characteristics, institutional and other determinants influencing technical inefficiency at the second stage using Tobit regression model. The findings are presented in table 3.

Table 3: Determinants of Technical Inefficiency in Smallholder's Oil Palm Production According to Crop Age

Determinants	Estimated Parameters	<9 years	9-18years	19 years & Above
Socio-economic Determinants:				
Constant	α_0	0.6493(2.79***)	0.7208(1.94*)	1.4434(8.52***)
Age of farmer	α_1	-0.0026(-0.63)	0.0029(2.98***)	-0.0103(-3.07***)
Age of farmer squared	α_2	0.0029(0.83)	-0.0048(-0.75)	0.0090(3.22***)
Educational level	α_3	0.0079(0.46)	-0.0051(-3.25***)	0.0011(2.04**)
Household size	α_4	0.0092(2.81***)	-0.0045(-1.33)	0.0035(2.94***)
Experience in farming	α_5	-0.0017(-2.82***)	0.0020(2.79***)	0.0015(2.63***)
Off-farm income	α_6	0.0377(1.25)	-0.0911(-1.46)	-0.0008(-3.08***)
Oil palm income	α_7	-0.0030(-0.14)	-0.0312(-0.89)	0.0024(1.71*)
Institutional Determinants:				
Government intervention	α_8	0.0485(3.93***)	-0.0065(-0.41)	-0.0115(-2.14**)
Access to credit facilities	α_9	0.0164(1.37)	0.0542(2.96***)	0.0233(6.73***)
Extension contacts	α_{10}	0.0372(3.33***)	-0.0060(-0.33)	0.0057(1.39)

Table 3....

Membership of oil palm smallholders Association	α_{11}	-0.0072(-0.69)	0.0035(0.26)	-0.0079(-2.52**)
Other Determinants:				
Age of oil palm	α_{12}	0.0276(1.69*)	0.0372(1.00)	-0.0214(-1.59)
Age of oil palm Squared	α_{13}	-0.0018(-1.21)	-0.0013(-0.86)	0.0005(1.62)
Land clearing	α_{14}	0.0085(0.65)	0.0133(0.56)	-0.0068(-0.73)
Fertilizers used	α_{15}	0.0035(3.02***)	-0.0015(-0.94)	-0.0012(-2.26**)
Pests & weed control method	α_{16}	-0.0299(-1.79*)	0.0943(4.88***)	-0.0127(-2.04**)
Soil conservation practices	α_{17}	-0.0250(-1.16)	0.0415(1.65*)	-0.0031(-0.39)
Replication of pesticides application	α_{18}	-0.0120(-1.89*)	0.0141(0.93)	0.0058(2.28**)
Log Likelihood		231.45	192.05	463.57
n		150	150	150

Figures in parentheses represents t-value

*= Significant at 10%, **= Significant at 5%, *** = Significant at 1%

The finding of the determinants of technical inefficiency in smallholder's oil Palm production according to age of crop in Peninsula Malaysia in table 3 shows that the coefficient of age of oil palm smallholders under 9-18years of crop age categories was positive while those under 19years and above have negative and are all significant at 1%. The positive coefficient of the age variable implies that technical inefficiency likely increases with increase in oil palm smallholder's age. That is, oil palm smallholders tends to be technically inefficient as they grow old. This is plausible, because the old farmers are primitive and conservative in readiness to adopt improved farm practices and other technologies (Amos *et al.* 2004; Dao, 2013). While the negative coefficient of the age variable means old smallholders are likely to be technically efficient than their younger ones. This is probably due to the fact that old oil palm smallholders under 19years and above crop age have gathered more experience in oil palm farming over the years than the younger ones and thus likely to be more productive and efficient (Dao, 2013).

The age of farmer squared was positive and significant at 1% for oil palm smallholders under 19years and above crop age. The positive coefficient of age of farmer squared implies that old smallholders are likely to be technical inefficiency than young ones. This finding suggests certain backing for the 'life cycle' hypothesis (Henderson & Kingwell, 2002), where the technical efficiency or inefficiency of the farmer is likely to increase at initial stage with age and later decrease as the farmer grows older beyond the mid age. The significance of the age squared means the relationship between farmer age and technical efficiency or inefficiency could be regarded quadratic. That is, increases initially with age and then decreases with age. The quadratic relationship indicated by age squared variable creates a small number of restraining assumptions together with the proportion of increase and decrease of technical efficiency with farmer age is symmetrical (Tauer, 1984; Tauer, 1995).

Education was negative for oil palm smallholders under 9-18years of crop age categories while those under 19years and above was positive and were significant at 1% and 5% levels respectively. The negative coefficient of the education means that oil palm smallholders who must have spent more years of formal education are likely to be less technically inefficient than those who spent less years of education. The plausible because, oil palm smallholders with more years of formal education have better understanding and adopt improved farming techniques which likely take them closer to the production frontier. Besides, education enhances farmer's ability to process the information required to apply 'best practices (Ajibefun & Aderinola 2004; Chinwuba & Emmanuel, 2006). While the positive coefficient of education implies that the more educated the oil palm smallholder is, the more inefficient the smallholder would likely be. This could be due to the fact that smallholders who were more educated were likely to be permanently employed and do oil palm farming on a part time basis, thus would be inefficient in their oil palm production (Malinga *et al.*, 2015).

Household size was positive and significant at 1% for oil palm smallholders under 9-18years and 19years and above crop age categories. The positive coefficient of household size means oil palm smallholders with large number persons in their household tend to be technically inefficient. This could be due to the fact that an increase in number of persons in the household leads to an increase in household consumption expenditure, which would carry away some proportion of the household income meant for the procurement of modern farm inputs and other farm operations which leads to technical inefficiency (Daniel *et al.,* 2015).

Experience in oil palm farming was negative for oil palm smallholders under <9 years crop age category while 9-18years and 19years and above were positive and were all significant at 1% level. The negative coefficient of farming experience implies that as oil palm smallholders experience in farming increase, technical inefficiency in oil palm production would likely decrease (Onu *et al.,* 2000). The positive coefficient farmers experience implies that as experience increases technical inefficiency will likely increase, which sounds illogical. This might be due to the effect of age of the farmer (Reddy & Sen, 2004). This is probably due to the fact that farmers with more years of farming experience are old people.

Off-farm income was negative and significant at 1% for oil palm smallholders under 19years and above crop age category. The negative coefficient of off-farm income suggests that oil palm smallholders with no off-farm income were more technically efficient than smallholders that have off-farm income. This could be due to less time that will be spent on the farm by the smallholders who have off-farm incomes and probably less efficient use of farm inputs (Tipi *et al.,* 2009). Oil palm income was positive and significant at 10% for oil palm smallholders under 19years and above crop age category. The positive coefficient of oil palm income implies that smallholders who earn higher income from oil palm production were likely to be technically inefficient than low income earners. This might be due to the fact that oil palm smallholders with larger household sizes put more pressure on the limited incomes obtained in oil palm production and this appears to worsen their poverty status. In addition, smallholders with larger household sizes spent more on food and other household basic needs. These poor smallholders are more likely to be technically inefficient in oil palm production since they cannot afford to purchase improve inputs such as fertilizer, seeds etc., that could increase output (Mango *et al.*, 2015).

Government intervention inform of subsidy was positive for oil palm smallholders under <9years of crop age category while those under 19years and above was negative and were significant at 1% and 5% levels respectively. The positive coefficient of government intervention suggests that oil palm smallholders who benefited from subsidies for oil palm production from the government were likely to be technically inefficient than those who did not benefit. This is probably due to the fact that subsidies could likely result in technical inefficiency if they are taken by the smallholders as high income which would results to slack, a lack of efforts and unwillingness to look for cost improving techniques (Rizov *et al.,* 2013; Leibenstein, 1966). In his study Kornai (1986) also indicated that subsidies could contribute increase to soft budget restrictions, which will leads to technical inefficient inputs use. Thus, subsidy increases technical inefficiency in smallholder's oil palm production. While negative coefficient of the subsidy variable means that oil palm smallholders who benefited from subsidies for oil palm production from the government were technically efficient than those who did not benefit. This further indicates that subsidies provided for oil palm smallholders as motivations to efficient usage of farm inputs to increase productivity, thereby making them technically efficient. Subsidy therefore reduces technical inefficiency of oil palm smallholders.

Access to credit facilities was positive and significant at 1% for oil palm smallholders under 9-18years and 19years and above crop age categories. The positive coefficient of access to credit facilities implies that smallholders who have more access to credit facilities were likely to be technically inefficient than those who do not have access. This implies that access of credit increases technical inefficiency in smallholder's oil palm production. This could probably be due to the inappropriate utilization of credit by the smallholder. Oil palm smallholders were expected to use credit facility for purchasing inputs, expand oil palm cultivated areas etc., so as to increase output (Alwarritzi *et al.,* 2015). According to Binam *et al.* (2004) indicated that if farmers have properly taken the advantages of credit facilities, it would possibly enhance the capability of the farmers to adopt new technologies and thus improve their efficiency.

Extension contacts was positive and significant at 1% for oil palm smallholders under <9years of crop age category. The positive coefficient of extension contact suggests that oil palm smallholders who have obtained services from agricultural extension workers or attended seminars/workshops are more likely to be technically inefficient. Even though agricultural extension services and farmer-extension education programs stand important policy tools for government to increase agricultural output, hitherto, numerous viewers (Binam *et al.,* 2004), reported poor performance in the services of extension and informal education methods, owing to administrative ineffectiveness, lacking package plan, and a number of broad weaknesses in-built in publicly operated, staff-intensive, information conveyance methods. In addition, the type of extension services rendered to the oil palm smallholders seems unsatisfactory which would consequently leads to technical inefficiency (Ofori-Bah & Asafu-Adjaye, 2011).

Membership of oil palm smallholder organization was negative and significant at 5% for oil palm smallholders under 19years and above crop age category. The negative coefficient implies that technical inefficiency likely reduces with oil palm smallholder being member of oil palm smallholder's organization. The significance of membership of oil palm smallholder organization cannot be overemphasized (Tchale, 2009), because farmers who are members in an organizations would get advantage not only from the mutual knowledge among themselves in the areas of new farming techniques, have more access to agricultural information, credit and economies of scale in accessing production inputs, as well as more improved ability to adopt innovations (Bhatt & Bhat, 2014). Thus member oil palm smallholders tend to be likely technically efficient than non-members.

Age of crop variable was positive and significant at 10% for palm smallholders under <9years of crop age category. The age of crop squared was negative for oil palm smallholders under <9years of crop age and 9-18years while those under 19years of crop age categories, but were all not significant. The positive coefficient of age of crop variable implies that inefficiency likely increases with increase in the age of the palm trees. This means oil palm trees tends to be inefficient in productivity as they grow older. As the palm trees grow beyond middle age, its yield continue to decline. The negative coefficient of age of crop squared though not statistically significant implies that older palm trees are likely to be inefficient in productivity than young palm trees. This finding suggests certain backing for the 'life cycle' hypothesis, where the efficiency of the palm trees is likely to increase at young age and later decrease as the crop grows older beyond the middle age.

Fertilizer used was positive for oil palm smallholders under <9years of crop age category while those under 19years and above was negative and were significant at 1% and 5% levels respectively. The positive coefficient of fertilizer used implies that technical inefficiency likely increases with increase in the amount of fertilizer use. The inefficiency might be due to the fact that oil palm trees at <9years of crop age are still young. Hence, the more fertilizer use the higher the level of technical inefficiency among the oil palm smallholders. The negative coefficient of fertilizer used means that technical inefficiency likely reduces with increase in the amount of fertilizer use by the oil palm smallholders under 19years and above crop age category. This is probably due to the fact that smallholders who have old aged crops apply large quantity of fertilizer to maintain their crop. In agricultural crop production, fertilizer is an improved input that moves the farmer's production towards the frontier resulting in higher technical efficiency (Hussain, 1989; Okoye *et al.*, 2008).

Pest and weed control method was negative for oil palm smallholders under <9years of crop age and 19years and above while 9-18years of crop age categories had positive coefficient and were all significant at 10%, 5% and 1% levels respectively. The negative coefficient of pest control method suggests that technical inefficiency likely reduces with the use of pest control method such as biological among the oil palm smallholders under <9years crop age and 19years and above crop age categories. The positive coefficient of pest control method implies that technical inefficiency likely increases with the use of pest control method such biological among oil palm smallholders. Soil conservation practices was positive and significant at 10% for oil palm smallholders under 9-18years of crop age category. The positive coefficient of soil conservation practices implies that technical inefficiency likely increases as the oil palm smallholders practice soil conservation practices. Though, soil conservation practice could reduce technical inefficiency by improving the soil fertility status (Solís *et al.,* 2007; Rahman & Hasan, 2008). The increased level of technical inefficiency due to soil conservation practices among the oil palm smallholders might probably be due to mismanagement practices that results in dampening.

Replication of pesticides application was negative for oil palm smallholders under <9years crop age category while those under 19years and above had positive and were significant at 10% and 5% levels respectively. The negative coefficient of replication of pesticides application suggests that technical inefficiency likely reduces with the replication of pesticides application among the oil palm smallholders while the positive coefficient of replication of pesticides application implies that technical inefficiency likely increases with the replication of pesticides application among oil palm smallholders. The above positive relationship could probably be due inefficient application of pesticides by the oil palm smallholders in the study area.

CONCLUSION

Malaysian palm oil industry's size of exports recorded a drop, though there was high returns due to mainly high price. ''The palm oil exports and derived products cut down to 25.1 million tons or by 2.5 percent from 25.7 million tons year-on-year. But earnings from palm oil increased by 3.7 percent to RM63.6 billion from RM61.4 billion in 2013 ‘’. While the mean crude palm oil price went up by a small increase of 0.5 percent over the relative periods. The study concludes that under the current underlying oil palm smallholders’ production technology, oil palm farms under 19years and above age of crop may possibly reduce large quantity of inputs followed by those under <9years crop age category and continue to produce the same bundle of output. The study revealed that smallholders under 9-18years crop age categories have the lowest prospects of inputs reduction followed by those under <9years crop age. While smallholders’ with 19years and above crop age categories having the highest inputs reducing potentials to enhance oil palm production efficiency; and oil palm smallholders under the three crop age categories operates at constant return to scale in the study area. The finding of analysis of variance (ANOVA) shows that there was significant difference in mean technical efficiency among the oil palm smallholders according to crop age in the study area.

The result of determinants of technical inefficiency among oil palm smallholders according crop age shows that government intervention, fertilizer used, extension contact and age of oil palm positively influence technical inefficiency among oil palm smallholders under <9years crop age category while household size have positive relationship with technical inefficiency among smallholders under <9yeas and 19years and above crop age categories. The study also indicates that age of farmer, educational level, experience, pest and weed control, soil conservation practices positively influence technical inefficiency among oil palm smallholders under 9-18years crop age category while access to credit facilities have positive relationship with technical inefficiency among oil palm smallholders under 9-18years and 19years and above crop age categories. Furthermore, oil palm income and replication of pesticides application have positive relationship with technical inefficiency among oil palm smallholders under 19years and above crop age category in the study area.

The study also re-affirmed the claim that experience in farming and replication of pesticides application have negative relationship with technical inefficiency among smallholders under <9years crop age category while pests & weed control method had negative influence on technical inefficiency among oil palm smallholders under both <9years and 19years and above crop age categories in the study area. The study further shows that age of farmer squared, educational level, government intervention, and fertilizer used, off-farm income and membership of smallholder organization have negative influence on technical inefficiency among oil palm smallholders that were under19years and above crop age category in the study area. The study was limited to independent oil palm smallholders in the State of Johor in Peninsular Malaysia and the difficulties encountered during data collection were poor of record keeping and inadequate finance to cover most parts of Malaysia. Based on findings of the study we recommend policies such as increasing oil palm smallholder's farm sizes to enhance their technical efficiencies in the study area. There is need to re-strategies the extension program for effective monitoring and supervision of the oil palm smallholders' in order to ensure that they comply with recommended inputs use especial those under <9years and 9-18years crop age categories to enhance their levels in the study area. There is need for member oil palm smallholders under <9years and 9-18years crop age categories to improve participation in association activities.

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